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NASA Space Station Needs, Attributes, and Architectural Options

FINAL STUDY REPORT

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ATTACHMENT 2, VOLUME II

Supporting Data and Analysis Reports

Prepared For **NASA Headquarters Washington, D.C.**

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FINAL STUDY REPORT

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ARCHITECTURAL IMPACT ANALYSIS

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FUNCTIONAL NEEDS TRANSLATED INTO ARCHITECTURAL DRIVERS

Upon completion of the development of the basic scenarios, a number of station influencing impact factors were identified. This effort resulted in the identification of some 23 categories within which numerous sub-category impact drivers were listed. The opposite page illustrates these categories within which numerous sub-category items were examined. Each of the items were then evaluated and where possible quantitative numbers/values, etc. developed for each. This permitted the analyst to then 'determine' the overall impact on the station through the use of a rating score (low-medium-high). The results of this analysis were then promulgated to the architectural design team and used as a basis for preparation of basic input criteria and guidelines.

The following 23 pages are included to provide the reader with the overall assessment effort overview. Areas (to the left of the page) are identified for each category, the influences indicated for each area, and a qualitative judgement made in the right column relative to the significance of the influence, e.g., high, medium, or low. Results of this evaluation are made in the main body of this volume within the Task 2 effort.

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OVER 280 INDIVIDUAL POTENTIAL STATION IMPACT INFLUENCERS EXAMINED

A. INFLUENCE IMPACT CHARACTERIZED FOR EACH CATEGORY ELEMENT
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 - HIGH
 - MEDIUM
 - LOW
C. LOW ITEMS SCREENED OUT
D. HIGH/MED IMPACTS PRIORITIZED

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SPACE STATION PROGRAMS

ENVIRONMENT

AREAS	INFLUENCES	RATING (HML)
• ALTITUDE (nmi)		
• - 200 to 300	NOMINAL HEIGHT - NO MAJOR IMPACT	L
• - 600 to 900	BEYOND STD. ORBITER OPERATIONAL RANGE WITH HEAVY P/L	H
- - 20,000 +	BEYOND STD. ORBITER OPERATIONAL RANGE WITH HEAVY P/L	H+
INCLINATION (deg)		
- 28 to 30	NOMINAL LAUNCH - NO MAJOR IMPACT	L
• - 55 to 60	VAB LAUNCH - REDUCED WEIGHT TO ORBIT	M+
- 90	VAB LAUNCH - SIGNIFICANTLY REDUCED WEIGHT TO ORBIT	H-
RADIATION SHIELDING	SIGNIFICANT IMPACT AT HIGHER ALTITUDES; WEIGHT FACTOR	H-
ORBITER ACCESS	LIMITED TO LEO ALTITUDES OF LESS THAN 400 nmi	H+
• LOGISTICS ACCESS	ORB. SUPPLY OF LOGISTICS LIMITED AS ABOVE; ABOVE 300-400 nmi NEW S/C	H+

SPACE STATION PROGRAMS

SHUTTLE MANIFESTING

AREAS	INFLUENCES	RATING (HML)
• NO. OF CARGO BAY LOADS	AVAIL. OF ORBITERS, LAUNCH/REFURBISH COSTS, ON-ORBIT OPS ASSY. COMPLEXITY	H+
• XFER OF CARGO TO STA.	NO. OF ITEMS; PACKAGING/ENVIRON. CONSTRAINTS; CARGO BAY USE; OPS COMPLEXITY	M+
• RMS OPS ENVELOPE	REACH CAPABILITIES; OPS COMPLEXITY; 50' DOME VOLUME; MASS HANDL.	M+
• XFER OF 'MODULES'	MASS HANDLING; ENVELOPE CONSTRAINTS; POSITIONING ACCURACY	M+
• BAY PKG CONSTRAINTS	15' x 56'; ENVIRON. PROTECT.; CONFIGURATION; MASS/CG CONSTRAINTS	L+
• MAX WEIGHT LIMITS	ORBITER TO LOCATION - ALTITUDE/INCLINATION; 65K lb MAX LIMIT	M+
• ON-ORBIT TIMELINE CONSTRAINTS	ORBITER STAY TIME (PWR); CREW PROVISIONS; PWR SUPPORT TO P/Ls	M-
• DOCKING ENVELOPE CONSTRAINTS	IMPACT GYRATION 10° MAX; 45° CONTACT CONE; 10° PLANE ABOVE P/L	H-
• ORBITER SERVICES PROVISIONS	INTERFACES, POWER LEVEL/AVAIL. (∼7 kW/4.4 DAYS), HEAT REJECT. 21.5k Btu/hr	M-
• RESUPPLY TIME PERIOD	SHUTTLE AVAIL.; ±TIME SPAN; CREW TURN-AROUND; ORBIT STAYTIME	H+

SPACE STATION PROGRAMS

LOGISTICS

AREAS	INFLUENCES	RATING (HML)
• DOCKING/BERTHING	IMPACT GYRATION 10° MAX; 45° CONTACT ZONE; 10° PLANE ABOVE P/L	H-
• STAGING FACILITY	ACCESS, FREE SWEPT VOL (UP TO 80' X 120'), TRACKS, BERTHING I/F	H-
• LIQUIDS/GAS TRANSFER	LINE LAYOUT; LENGTH; ΔP DROP; ACCESS I/F	L
• LIQUIDS/GAS STOWAGE	TANKAGE - SIZE/NO/LOCATION (ACCESS); SAFETY	M+
• INTERNAL PASS-THRU VOL. -XFER	SIZING (UP TO 48" DIA) - AIRLOCK/TUNNEL/HATCH	L+
• CONTAMINATION CONTROL	STAY-OUT ZONES; CONTROL	H-
• ENVIRON. CONDITIONING	TYPE; VOL. TO BE CONDITIONED; CONSUMABLES	L
• SCAVENGING	TECHNIQUE; MATERIAL; HANDLING; TRANSFER; SAFETY	L
• STOWAGE VOLUME	QUANTITY; STAGING; 'NEW VS DISCARDED'	M-
• INTERNAL/EXTER. STOWAGE	TYPE OF CONDITIONING (PRESSURE/TEMP); PROTECTION	L
• WEIGHT	ORBITER LIMITED 65K LBS; XFER LOG. VEH. CAN BE STA. FUELED	M-

SPACE STATION PROGRAMS

POINTING & CONTROL

AREAS	INFLUENCES	RATING (HML)
• EXPER/PROCESS POINTING	DEAD BAND ± 0.05(LOS); RATE DEG/SEC ± 0.01 (LIMITED TIME)	H-
• ORBIT DECAY MAKEUP	APPROX. $1_T = 0.76 \times 10^6$ LB/SEC; $W_P = 1800$ LB/M	M-
• SOLAR ARRAY TRACKING	FIELD-OF-VIEW;SHADOWING;DISTURBANCE 2.5×10^{-6} G's TO ARRAYS	H
• PRCS FIRINGS	CONTAM.;FREQUENCY;STABILITY PETURBERENCE;LOCATION;$\sim$10LB.	H
• DOCKING/BERTHING	CONTROL FREQ.ABOVE 0.1HZ;IMPACT VEL.0.1 FT/SEC;I/F MOMENT 16K FT/LBS	M+
• LOGISTICS HANDLING	HANDLING LOADS;STATION PETURBERENCE;FREQUENCY	M
• CREW MOTION	FREQUENCY;LOCATION;DISTURBANCE 0.026 G's	M
• ASSEMBLY/CONSTRUCTION	FREQUENCY;DYNAMICS/LOADS INDUCED TO STATION;STABILIZATION	M+
• PLUME IMPACT	FREQUENCY;PRESSURE;LOCATION;DAMPING	M
• MICRO-G MAINTENANCE/ STAB.	LEVELS (E.G. 10^{-4}G); DE-COUPLED NEEDS	H
• APPENDAGE SLEW MOTION/ RATES	FREQUENCY;DYNAMICS;LOCATION VS CG	L+
• MASS MOTION & DYNAMICS	ORIENTATION;LEVELS/RATES;MASS QUANTITIES;STRUCT.STIFFNESS	M+

APPROACH AND DEPART ENVELOPES

AREAS	INFLUENCES	RATING (HML)
• PLUME IMPINGEMENT		
- PRESSURE	QUANTITY (RANGE);DISTANCE (ORB IMPACT AT OVER 400',E.G.)	H
- CONTAMINANTS	TYPE;DENSITY FACTOR VS DISTANCE	M+
• FREE SWEPT VOLUME NEEDS		
- APPROACH	DIMENSIONS (CONE = 45° OUT TO 50', CYLINDER UP TO 28' DIA.)	H
- DEPART	DIMENSIONS (AS ABOVE)	H
• SHADOWING	FREQUENCY;LOCATION	L

SPACE STATION PROGRAMS

STATION ASSEMBLY

AREAS	INFLUENCES	RATING (HML)
• ORBITER-STATION RMS I/F	SERIAL USE-I/F; STABILIZATION; MASS (<60k LB); ACCURACY (±1.5 in.)	M+
• ORBITER RMS SWEPT VOL.	STAY-OUT ZONES; REACH DISTANCE (E.G., 40' ABOVE MOLD LINE)	M+
• ORBITER-STA. MECH. I/F	ORB. STABILIZATION; HOLDDOWN/POSITIONING; BAY TIE DOWN	L
• STA. ASSY. BUILDUP SWEPT VOL.	ORBITER INTERACTION; STA. ATTACHED RMS (50' DOME) & TRACKS	M+
• LOGISTICS I/F	DOCKING MODULE-LOCATION/NO. & FREE SWEPT VOL; PALLET ATTACHMENT	M
• APPROACH/DEPART SWEPT VOL.	S/C CONE (±45 OUT TO 15'); CYLINDERS UP TO 28'; FREE-SWEPT VOL.	M+
• ATTITUDE VS SHADOWING	SHADOWING FREQUENCIES/AREA; SA/RADIATOR SIZES	M+
• SIG/PWR CABLE INSTALL - I/F	RUN LENGTHS (ΔPWR DROP) & EMI; PROTECTION; OUTLETS - NO./LOCATION	L
• EVA ACCESS/ TRANSLATION	LOCATIONS; SAFETY; UTILITY OF ACCESS	
• ILLUMINATION & CCTV ACCESS	LOCATIONS; SHADOWING; SOLAR/LUNAR POSITION CONSTANTS	L
• HOLDING/POSITIONING	DYNAMICS; LOADS; MASSES (UP TO 300k LB); POSITIONING ACCESS	M-

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SPACE STATION PROGRAMS

MODULARITY

AREAS	INFLUENCES	RATING (HML)
• EVOLUTION	SIZING;ACCOMODATION FLEXIBILITY;CANDIDATE 15' DIA. CONSTRAINT	M+
• INTERCHANGEABILITY	PWR/SIG/FLUIDS I/F's; ORB.COMPATIBILITY;REFURBISHABILITY	L+
• ORBITER TRANSPORTABILITY	DIA (<15' DIA.); LENGTH (<56'); WT (<65K LBS); CG;BAY INSTALL.CONSTR.	M+
• GROWTH/ADD-ON	I/F COMPAT.;STRUCT.COMPAT.;MECH.MTG.;CREW XFER/ACCESS	L
• SIZING/VOLUME	LAUNCH SYS.COMPAT.;ADEQUATE INTERNAL VOL. VS NEEDS;WT.	H
• PRESS/UNPRESSURIZED	STRUCTURAL SIMILARITY;WT. PENALTY;SIZE LIMITS;RE-PRESS.NEEDS	L+
• MTG. FEATURES	LAUNCH;ORBITAL CONSTRUCT.;FLEX TO ACCOMODATE I/F OR ADD-ONS	L+
• SERVICES I/F	TYPE;QUANTITY;NO.;SAFETY;STANDARDIZATION I/F	L
• STANDARDIZATION	NO'S.;FLEXIBILITY NEEDS;COST VS STAND.	M-

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SPACE STATION PROGRAMS

HABITATS

AREAS	INFLUENCES	RATING (HML)
• SIZE ACCOMMODATIONS	NO. OF CREW: BASIC OPS EQUIP.; ECLSS; RAD. PROTECT.; FREE VOL.	H
• A/L ACCESS	ORB. COMPATIBLE; TWO SEPARATE A/L's FROM OPPOSITE HAB. 'ENDS'	M
• DIRECT DOCK ACCESS	1M CLEARANCE; ORB. I/F AT $Z_0$515 MIN./$X_0$619; PASSIVE MECH. ADAPTER	H-
• TUNNEL ACCESS	A/L TO TUNNEL I/F; 60" DIA. MIN.; CLOSE-OFF OF TUNNEL AT A/L	M-
• EVA AIDS & XLATION DEVICES	XLATION RAILS-LONGITUDINAL/CIRCUM.; FULL ACCESS OR WITH MMU; LIGHTS	L
• VIEW PORTS	NUMEROUS; IN HAB & LABS; 10-12" DIA.; FILTERS	L
• COMMON TUNNEL IFs	COMMON TO A/L's; OTHER TUNNELS, HAB/LAB	L+
• PALLET/PLATFORM MTG. IFs	SIMILAR TO DOCKING UNIT; SPECIAL MTG's FOR NON-MANNED ACCESS	M-
• SERVICES IFs	UTILITY AIRLOCK-MTG./PWR/SIGNAL/THERMAL/FLUIDS/COMM/O_2 & N_2	M-
• SERVICES ACCOMMODATIONS	CREW PROVISIONS & ECLSS; SIGNAL/PWR/COMM; MTG; THERMAL CONTROL	L+
• LOGISTICS IFs	VIA DOCKING UNIT; 60" DIA.; HANDLING MGMT.; ORB. I/F-DOCK& RMS	M
• INTERNAL SIZE PASS-THRU	NOMINAL 60" DIA.; FREE SWEPT CLY. VOL.; CREW AIDS; 36" ISLEWAYS	L+

SPACE STATION PROGRAMS

ENCLOSED VESSEL

AREAS	INFLUENCES	RATING (HML)
• INGRESS/EGRESS - 2 PATH	TWO PATH OPPOSITE END; TUNNEL OR A/L PROVISION	M-
• TUNNEL(S) I/F	STANDARD TUNNEL; 60" DIA. OPENING	L+
• VIEW PORT - UNOBSTRUCTED VIEW ANGLES	APPROXIMATELY 15° CONE AS A MINIMUM	L+
• UTILITY RUNS/DUCTS	MAINT. ACCESS; NOT WITHIN FREE SWEPT VOL; STANDARD UTILITIES	L
• INTERNAL MTG. STRUCTURE	STANDARD ATTACH FEATURES; REPOSITIONABLE	L-
• EXTERNAL MTG. STRUCTURE	STANDARD TECHNIQUE; COMPAT. WITH RMS HANDLING; AVAIL VOL; NO SHADOW	M
• PASS-THRU FREE SWEPT VOL.	STANDARD OPENING OF 60" DIA. & NO INCURSIONS; PERMITS SUITED CREW	L
• INTERNAL WORK FREE SWEPT VOL.	PERMITS 36" X 78" ISLEWAY; DUCTING NONINTERFERENCE	L
• DEDICATED EQUIP. VOL.	LOCATED TO PRESERVE MAX INTERNAL FREE SWEPT VOL.	L
• SIZING ACCOMMODATIONS	MEETS MISSION NEEDS; ORBITER BAY CONSTRAINT; POSSIBLE ASSY	M
• SAFETY FACTOR	MANNED = 2.0; UNMANNED = 1.5; PRESSURE VESSEL = 2.0	L

OPEN PLATFORM

AREAS	INFLUENCES	RATING (HML)
• MOUNTING I/F	STANDARD-INTERNAL/EXTERNAL SURFACE; EVA/RMS AS MTG. AGENT	L
• UTILITIES I/F	PERMITS STD. UTILITY PAN I/F; PROVIDES PROTECTION; STD TERMINALS	L+
• LINE-OF-SIGHT	CRITICAL I/F LOCATION MTG. TO STA.; SHADOW/PLUME/ OBSTRUCT. FREE	M+
• POINTING/ STABILITY	LIMITED TO STA. G&C FOR EXPER ∿±0.05 DEAD BAND & ±0.01 RATE (DEG/SEC)	M+
• EQUIP. MOTION - FREE SWEPT VOL.	PERMITS FREE MOTION WITH NO INTERFERENCE WITH STATION	M
• CONTAMINATION AVOIDANCE	MTD/PROTECTED FROM ORB./STA. RCS/STAGE PROPULSION	M+
• EVA ACCESS	BUILT-IN PROVISIONS ON STA.; CREW EVA/MMU ACCESS (COLD GAS PLUME)	L
• THERMAL CONTROL	REQUIRES 'PLUMBING' PROVISION; SUN-SHADE; PWR I/F	L+
• LOGISTICS I/F	RMS ACCESS; DOCING UNIT AVAIL.; EVA CREW ACCESS; LOG. VEH ACCESS	M
• SHADOWING SENSITIVITY	CRITICAL I/F LOCATION MTG. TO STA.; ORB APPROACH/DEPART	M+

APPENDAGES

AREAS	INFLUENCES	RATING (HML)
• SOLAR ARRAYS/BOOMS	ARTICULATION & FREE SWEPT VOL.; SHADOWING EFFECTS; PLUME IMPACT	H+
• RADIATORS	ARTICULATION & FREE SWEPT VOL.; THERMAL OUTPUT ENVELOPE; SHADOW	H
• EXTENSIBLE BOOM	AVAIL. FREE UNOBSTRUCTED VOL; COLLISION AVOIDANCE	M
• PRCS BOOMS	UNOBSTRUCT. LOCATION; NOZZLE PLUME ENVELOPE; COLLISION AVOID.	M+
• RMS	BASIC USE ENVELOPE; ENVELOPE I/F 'ON TRACKS'; ACCESS TO NEED POINTS	M+
• SENSOR BOOMS	AVAIL. UNOBSTRUCTED VOL; FIELD OF VIEW (LOS); COLLISION AVOIDANCE	M-
• TETHERED ITEMS	FREE SWEPT VOL.; COLLATERAL DAMAGE POTENTIAL; COLLISON AVOID.	M
• PIERS/BEAMS	NON-INTERFERENCE; MTG. LOCATION; STATION DYNAMICS IMPACT	M+
• TRACKS	LOCATION; I/F WITH TRACKED ITEM; INTERACTION ENVELOPE; MTG. I/F	M
• ANTENNAS/REFLECTORS	ARTICULATION-LOS; BEAM/RECEIVING PATTERN SHADOWING; PLUME; COLLISION	H
• SIZING	PACKAGING; CONFIGURATION; MECHANISMS; STIFFNESS (Hz); DYNAM/LOADS	M-
• ARTICULATION ENVELOPE	FREE SWEPT VOL; PROXIMITY; LOS; SHADOWING; PLUME SUSCEPTIBILITY	M
• FREE SWEPT VOLUME	DIMENSIONS; ANGLES; LOCATION; ADJACENT ITEMS; COLLISION AVOID.	M
• FREQ. OF ARTICULATION	OPS-EXPERIMT CONDUCT; PERTURBATION EFFECT VS TIME VS DAMPING	M-
• STAY-OUT AREAS	OTHER ITEM SHADOW/INTERFERENCE; IMPACT AVOIDANCE; BERTHING PORTS	M

SPACE STATION PROGRAMS

MECHANICAL PROVISIONS

AREAS	INFLUENCES	RATING (HML)
• RACKS/PALLET I/F's	LOCATION;STA.MTG.POINT AVAIL.;UTILITY I/F;LOADS/MASS/DYN/STIFFNESS	M
• PLATFORM I/F's	LOCATION;STA.MTG.POINT AVAIL;UTILITY I/F;LOADS/MASS/DYN/STIFFNESS	M+
• PIERS/BEAMS I/F's	LOCATION;MULTI-POINT MTG.;SIZE VS LOADS/MASS/DYN/STIFFNESS;ASSY	M+
• TRACK/RAIL I/F's	LOCATION;MULTI-POINT MTG.:MULTI-FUNCTION UTILITY;ASSY INSTALL EASE	M
• MECH. MTG. I/F's	AVAIL.STA.WALL/STRUCTURE STIFFNESS/ACCOMODATIONS;TERMAL;ACCESS	M-
• DUCTING I/F's	LOCATIONS;QUANTITY/TYPE UTILITIES;LAYOUT RUNS;ACCESS;MTG I/F	L
• CABLE TRAY I/F's	LOCATIONS;ACCESS;TERMINALS;MTG I/F;LAYOUT RUNS;ACCESS	L
• DOCKING/BERTHING UNIT(S) I/F's	MECH.MTG.;± 5 IN. MISS DISTANCE;± 4° MISS ANGLE;± 4° ROTATION ANGLE ANGLE	M+
• HOLDING FIXTURE(S) I/F's	STA.LOCATION;SIZE-LOADS/MASS/DYN./STIFFNESS;GRASPING PROVISIONS	L
• POSITIONING DEVICE(S) I/F's	STA.LOCATION;POSITIONING ACCURACY;ARTICULATION ANGLES	L-
• SHELTER(S) I/F's	STA.LOCATION;SIZE-LOADS/MASS/DYN/STIFFNESS;'OPEN/CLOSED'	M
• BOOM I/F's	STA.LOCATION;SIZE-LOADS/MASS/DYN/STIFFNESS;EXPAND/RETRACT	M

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CREW

• HABITABLE VESSELS	FREE VOL/PERSON; PROVISIONS; SAFETY; LOGISTICS	H-
• PASSWAYS	36" WIDTH (MIN.) X 78"; LOCOMOTION AIDS; ILLUMINATION; ACCOM. SUIT	L+
• AIRLOCKS	2-CREW PERSON ACCOM.; BASIC UTILITIES; 2 FULL REPRESS CYCLES (SAFETY)	M
• DUAL INGRESS/EGRESS	2 LOCATIONS ON EACH INHABITED MODULE FOR ENTRY/EXIT	M
• SAFETY SHELTER ACCESS	2 ROUTES AVAIL. TO GAIN ACCESS; HANDLES LEO RADIATION	M
• EVA/IVA ESCAPE PROVIS.	'SHELTER' AVAIL.; A/L ACCESS TO MAIN STA. BRANCHES; ACCESS TO RETURN VEH	M
• ECLSS SERVICES	14 PSI ENVIRON (2 GAS) PARTIAL PRESS.; NOMINAL & BACKUP; SHIRTSLEEVE ENVIRON.	M-
• POWER/SIGNAL I/Fs	STANDARD UTILITIES WITH 2-WAY COMM.; REDUNDANT CRITICAL FUNCTIONS	M-
• LOGISTICS RESUPPLY	APPROX. 800/1000 LBS/90 DAYS/PERSON-LESS IF REGENERATIVE ECLSS	M-
• DOCKING/TRANSFER	90 DAY CREW TURN-AROUND; IVA XFER FROM ORB TO/FROM STA. VIA DOCK. UNIT	M-
• VIEWPORTS	NUMEROUS; IN ALL HABITABLE SUB-ELEMENTS; 10-12" DIA. WITH FILTERS	L
• EVA ACCESS/TRANSLATION	TOTAL EXTERNAL STATION ACCESS VIA XLATION RAILS OR EMU	L
• WORK STATIONS	MODULAR; 19" RACK UNITS; RESTRAINT PROVISION; H.E. LAYOUT	L
• HABITABILITY PROVISIONS	FULL SHIRTSLEEVE; FULL FREE VOL MAX. ALLOCATION; MODULAR	M
• TRANSLATION VOL-IVA/EVA	MIN. 36" DIA. CYLINDER; BASIC 60" DIA HATCHES; FULL PRESS. SUIT COMPAT.	L+
• WORK AIDS/AUGMENTORS	COMPREHENSIVE KIT (E.G. ORBITER); MISSION GENERIC NEEDS	L
• CREW SIZE	NO.; MIX (MALE/FEMALE); ROTATION OVERLAP; STAY-TIME	H

COMMUNICATIONS INTERFACE

AREAS	INFLUENCES	RATING (HML)
• ANTENNA/REFLECTOR	NOS.(3-4); SIZES (1-10 METER DIA.); LOCATIONS VS LOS	H
• DYNAMIC MOTIONS	STA. INDUCED; POINTING & HOLD ACCURACIES; STIFFNESS (Hz)	M+
• LINE-OF-SIGHT	UNOBSTRUCTED FIELD OF VIEW; RADIATION PATTERNS (SEND/RECEIVE)	M
• SHADOWING	ENCUMBRANCES (STA., S/A, ATTACHED MODULES, BOOMS, PLATFORMS)	M+
• LINK AVAILABILITY	POINTING (TIME/LOS/FREQ) TO TDRSS/ORB/OTV/EVA/SATS/FREE FLYERS	M+
• SIZING	SIZE & NO.; LOCATION; AUTO VS EVA ASSY.; OUTPUT CHARAC.; DYNAMICS	M
• INTERFERENCE FACTORS	EMI INCOMPATIBILITY; PLUME DEBRIS; SHADOWING	M
• PWR/CABLE LENGTH/ PROTECTION	RUN DISTANCE VS SIGNAL STRENGTH DROP;ACCESS; ENVIRON.PROTECT.	M-
• PROXIMITY - ANTENNA/ REFLECTOR	PROXIMITY TO DOCKING PORTS;COLLISON AVOID.; OTHER SIGNAL INTERFER.	M
• CONTAM. SENSITIVITY - ANTENNA/REFLECTOR	PLUME DEBRIS; STATION VENTING; MANUFACT/ASSY DEBRIS/CONTAM.	M-
• POWER	QUANTITY (∿.25 TO 35 kW); APPROX 80% IS 120/208V 3-PHASE 400 CYCLES	M-

MISSION HARDWARE SUPPORT

AREAS	INFLUENCES	RATING (HML)
• DOCKING/BERTHING	IMPACT GYRATION 10° MAX; 45° CONTACT CONE; 10° PLANE ABOVE P/L; IMPACT 0.1 FT/SEC	M+
• UMBILICAL-SERVICE I/Fs	FULL UTILITIES-MTG., PWR/SIG/THERMAL/FLUIDS/COMM	M-
• MECHANICAL MTG. I/F	AVAIL. STA. WALL STRUCTURE STIFFNESS/ACCOMMODATIONS; THERMAL I/F; ACCESS	M
• POINTING/STABILITY	DEAD BAND ±0.05° (LOS); RATE DEG/SEC ±0.01 (LIMITED); MICRO-G (10^{-4}G)	H
• ASSEMBLY MOUNTING I/F	MOUNTING PIER/FIXTURE-STIFFNESS (<1Hz), LOADS, DYNAMICS, MASS & STABILITY	M
• ACCESSIBILITY TO H/W	IVA & EVA; LOGISTICS XFER; MAINTENANCE; RMS REACH	M
• CONTAMINATION CONTROL	STA. VENTING; PLUME EJECTA-STA. RCS, ORBITER, OTV, MANEUV. SATS	M-
• LOGISTICS I/F	AVAIL. DOCKING UNITS; PASS-THRU VOL; STOWAGE AVAIL.; ENVIRON. CONDITION	M
• COMMAND/MONITOR & C/O	PWR (<0.2 kW); UTILITIES AVAIL.; CREW TIME; H/W/WT; UTILITY I/Fs	L+
• DATA HANDLING/ RETRIEVAL/MGMT	THRU-PUT RATES; PROCESSING; STOWAGE; XMIT VIA TDRSS (AVAIL)	M-
• THERMAL CONTROL	LOCATION AVAIL.; QUANTITY (1-5 kW); PEAK VS CONTINUOUS LOADS; ECLSS IMPACT	M
• POWER	6-8 kW (AVER.); 9-10 kW UP TO 1 HR 3 TIMES/DAY; 10-12 kW UP TO 1-2 MIN/HR	H
• ENVELOPE/ FREE SWEPT VOL	S/C DOCKING; ATTACHED P/Ls; ASSY.; RMS SWEPT VOL. ACCESS; FREE LOS	M+
• LIQUID/PRESSURANT SERVICE	LOCATION AVAIL.; RATE/QUANTITY/TYPE	M-
• ANTENNAS/REFLECTORS	FREE LOS; MIN. CONTAMINATION/INTERFERENCE; STIFFNESS/DYNAMICS	M

SPACE STATION PROGRAMS

SUPPORT ELEMENTS

AREAS	INFLUENCES	RATING (HML)
• LIQUID/PRESS. STOWAGE	TANKAGE (NO., TYPE & SIZES); SAFETY (PROXIMITY & TYPE LIQUID HANDLING)	H
• LIQUID/PRESS. XFER VALVES/LINES	LOCATION; REDUNDANCY; SAFETY; MAINT ACCESS; FLOW RATES	M-
• TETHER CABLES/REELS	ITEMS (LOOSE VS SECURE); COLLATERAL DAMAGE POTENTIAL; OPS IMPACT	L+
• MICROWAVE ANTENNA(S)	QUANTITY; SIZE; FREE LOS; CONTAMINATION/INTERFERENCE; MTG/STIFFNESS	M
• RACKS/PALLETS	STA. I/F LOCATION; FREE LOS; RMS REACH; SHADOWING STABILITY	M
• PLATFORM(S)	STA. MTG LOCATION; FREE LOS; SHADOWING; STABILITY; STIFFNESS	M+
• TRACKS/RAILS	LOCATION; I/F WITH TRACKED ITEM; INTERACTION ENVELOPE; MTG I/F	M
• DOCKING/BERTHING UNITS	MECH. MTG.; ±5 in. MISS DISTANCE; ±4° MISS ANGLE; ±4° ROTATION ANGLE	M+
• AIRLOCKS	NO.; 2-CREW ACCOM.; BASIC UTILITIES; 2 FULL REPRESS CYCLES	M
• TUNNEL(S)	BETWEEN MODULES; 60 in. DIAM. HATCH; LOCOMOTION AIDS; LIGHTS UNRESTRICTED	L+
• HOLDING FIXTURE(S)	STA. LOCATION; SIZE-LOADS/MASS/DYN/STIFFNESS; GRASPING PROVISIONS	L
• POSITIONING DEVICE(S)	STA. LOCATION; POSITIONING ACCURACY; ARTICULATION ANGLES	L-
• SHELTER(S)/HANGAR(S)	LOCATION; NOS.; SIZE-LOADS/MASS/DYN/STIFFNESS; OPEN/CLOSED; SHADOW	M
• BOOMS	STA. LOCATION; EXTENSION RANGE; ARTICULATION; STIFFNESS; ENVELOPE	M
• DEFENSIVE MODULE	LOCATION; SIZE/MASS; FREE LOS; MTG. I/F; CONTAMINATION SENSITIVITY	M+

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SPACE STATION PROGRAMS

SUPPORT ELEMENTS (Continued)

AREAS	INFLUENCES	RATING (HML)
• SUPPORT SUBSTATIONS	LOCATION (IV/EV); CREW SIZE; UTILITIES REQD; INSTALLATION I/F	L+
• STAGING FACILITY	LOCATION; PLUME ENVELOPE; RMS/CRANE ACCESS; SIZE (DIAM./LENGTH) PROTECTION	M+
• SAFE HAVEN	CREW ACCESS ROUTES; SIZING (NO. OF CREW); ECLSS PROVISIONS; ORB. ACCESS	M+
• ESCAPE MODULE	CREW ACCESS; SIZING (NO. OF CREW); ECLSS PROVISIONS, LOCATION	M
• LOGISTICS STOWAGE UNIT	LOCATION; RMS/CRANE ACCESS; CREW (IV/EV) ACCESS; ENVIRON. PROJECT: SIZE	M
• POWER CELL ADD-ON(S)	RADIATION POTENTIAL; SIZE; LOCATION; SWEPT VOL.; UTILITY I/Fs: MTG.	M+
• STAGE CARRIAGE ASSY.	LOCATION; RMS/CRANE ACCESS/HANDLING; SWEPT VOL; UTILITY I/Fs	M+
• BEAMS/PIERS	MTG. I/F; SWEPT VOL; DYNAMICS/LOADS/MASS; RMS/CRANE I/F	H-
• SERVICING UNIT	LOCATION; S/C SIZE ACCOMMODATION; UTILITIES I/F; SPARES ACCESS; SAFETY	M+
• SPARES STOWAGE UNIT	LOCATION; RMS/CRANE ACCESS; ENVIRON. PROTECT.; SIZE; CREW ACCESS	L+
• MANIPULATOR/CRANE ASSEMBLY	LOCATION; TRACKS; SWEPT USE ENVELOPE; ACCESS/WORK RANGE; SIZE; UTILITIES	H-
• RMS	LOCATION; SIZE/REACH/MASS HANDLING; REMOTE OPS; COLLATERAL DAMAGE POTENTIAL	H-
• CLOSED CHERRY PICKER	LOCATION; VIEWING; ILLUM.; TRACK; SWEPT USE ENVELOPE; UTILITIES I/F	M
• CONSTRUCTION BASE	MTG. I/F; DYN/MASS/LOADS; ENVELOPE; RMS/CRANE ACCESS; SHADOWING	H-
• SUNSHADES	MTG. I/F; LOCATION; SIZE/MASS; ARTICULATION; CONFIG.; TRANSPORTABILITY	L-

SERVICING AND STAGING SUPPORT

AREAS	INFLUENCES	RATING (HML)
• DOCKING/BERTHING	SWEPT VOL; 45° CONTACT CONE; 10° PLANE ABOVE P/L; IMPACT 0.1 FT/SEC.	M+
• UMBILICAL-SERVICE I/Fs	FULL UTILITIES; PWR/SIG/THERMAL/FLUIDS/COMM	M-
• MECHANICAL MTG. I/F	DOCK. UNIT/HANGER/WK PLATFM MTG. I/F; WALL STRUCT/STIFFNESS	M
• TRANSLATION DEVICE	AVAIL. OF RMS/CRANE/TRACK WITH MOTIVE SOURCE	M+
• FREE SWEPT VOLUME	RMS/CRANE WORK ENVELOPES; S/C & LOG.HANDLING; APPROACH/ DEPART VOL.	M+
• SIZE ACCOMMODATION-S/C & STAGE	DIA. UP TO 27.5'; LENGTH UP TO 120'; 2 SIDE BY SIDE DIAS. OF 14.5' EA.	H
• MANIPULATION/XFER TECH	S/C HANDLING-ANGULAR/ROTATION; RMS/CRANE MANEUV OF S/C; TRACKS	M-
• APPROACH/DEPART ENVEL.	S/C UP TO 27.5' DIA.; DOCK/UNDOCK CONE 45° OUT TO DIA.; PLUME IMPACT	M+
• SPARES STOWAGE ACCESS	RMS/CRANE REACH; EVA CREW ACCESS WITH RESTRAINED XFER; PROXIMITY	M
• LIQUIDS/PRESS. TANKAGE	TYPE; UP TO 60K LBS INITIAL; NO. OF TANKS (2-4); DIA/LENGTH; SAFETY	H
• LIQUIDS/PRESS. XFER SYS	SAFETY; UMBILICAL I/F; RUN LENGTHS (DIST.); REDUNDANCY; MAINT. ACCESS	L+
• S/C-STAGE C/O & MONITOR	UMBIL. HANDLING-I/F; AT-SITE VS REMOTE; PWR. (0.5 KW); SAFETY	L
• EVA ACCESS & TRANSLATION	XFER PATHS; XLATION AIDS; MMU ACCESS; WK ACCESS ENVELOPE; SAFETY	L
• WORK STATIONS	PORT. VS FIXED; UMBIL I/F; REMOTE I/F; EVA CREW ACCESS VS WK PROXIMITY	L
• ENVIRON. PROTECTION	PLUME IMPACT; SOLAR (UP TO 90° β ANGLE); IMPACT DAMAGE: DEBRIS	M-
• SERVICE/STAGE SHELTER	TYPE (OPEN MESH/FRAME/ENCLOSED); SIZE (UP TO 40' DIA); NO.;LOCATION	M+

SPACE STATION PROGRAMS

SUPPORT SERVICES & UTILITIES

AREAS	INFLUENCES	RATING (HML)
• SAFE HAVEN	'MODULE(S)' SIZED FOR ON-BOARD CREW; RETREAT AREA; ADDED ECLSS	M+
• RETURN CAPSULE	DOCKED PORT AVAIL.; CREW SIZED/NO.; APPROACH/DEPART ENVELOPE	M
• DEFENSE MODULE	BERTHED POINT AVAIL.; UTILITIES SUPPORT; EXIT ENVELOPE; STATUS MON.	M
• 2 PATH ENTRY/EXIT FROM MODULES	TUNNEL(S)-NO., LENGTH/DIA,LOCATION; I/F TO A/L's; INTERFER. ENVELOPE	M+
• FREE VOL.-SWEPT ENVELOPES	RESCUE VEH. APPROACH/DOCKING; RMS MODULE TRANSFER	M
• COSMIC/SOLAR FLARE PROTECTION	AVAIL. SAFE HAVEN; RAD. PROTECT.; ACCESS VS TIME (PROXIMITY)	M
• MICRO-METEORITE PROTECTION	CAPABILITY; PRESSURE LOSS; SAFETY SHELTER; ALTER. HABITAT	M
• DOCKING MODULE/AIRLOCK	NO., AVAIL.; LOCATION; NO. OF CREW ACCOMMODATIONS; ACCESS EASE	
• 2ND HABITABLE VOLUME	AVAIL.; ACCESS.; NO. OF CREW CARRYING CAPACITY	H-
• EMERGENCY LOGISTICS	QUAN. VS CREW SIZE; AVAIL/LOCATION; RESUPPLY	M-
• SHIELDING	ALT & SOLAR FLARE DEPENDENT; LOCATION/ACCESS; QUANTITY	M-
• EXTENDS HAZARDS AWAY	HAZARD TYPE; EXTENT; EXPOSURE LEVEL ACCEPTABILITY; DYN/LOADS	M-

SPACE STATION PROGRAMS

SUPPORT SUB-STATIONS

AREAS	INFLUENCES	RATING (HML)
• MANNED MANEUVERING UNIT	STD. ORBITER ITEM;2 PROVIDED ADJACENT TO OPPOSITE END AIRLOCKS	L-
• PROXIMITY OPS UNIT	INTERNAL C/O STA(1);1 EXTERNAL MTG-I/F SUB-STATION;PLUME	L
• SPACE PLANE	MAJOR DOCK/SERVICE PORT;1 INTERNAL C/O STA.;MAJOR UTILITY I/F's	L
• OTV/MOTV	MAJOR DOCK/SERVICE PORT (UP TO 2);1 INTERNAL C/O STA; MAJOR UTIL.I/F's	L
• TELEOP. MANEUVERING SYS	UP TO 2 BERTHING I/F's; 1 INTERNAL C/O STATION;MAJOR UTILITIES I/F	L
• TETHERED MODULE	1 UNIT AT A TIME;1 INTERNAL C/O & OPS STATION; NO UTILITIES I/F	M
• INTER-ORBIT TUB/SCOOTER	MAJOR DOCK PORT;1 INTERNAL C/O STA;MAJOR UTILITIES I/F	L
• LIQUID/PRESSURANT XFER	BOTH ATTACHED &/OR REMOTE;1 EV & 1 IV LOCATED C/O & OPS STA; UTILITIES I/F	L
• SERVICING UNIT	SUPPORT FOR CREW EVA;UMBILICAL-LINE TO INTERNAL LOCATED C/O-OPS STA.	L
• FREE SWEPT VOLS. FOR SUB-STA's	MAX SWEPT VOL ∿36" x 54" x 22" (POSITIONING ARTICULATION)	L-
• APPROACH/DEPART FREE SWEPT VOL.	I/F TO SUB-STATIONS LIMITED TO UMBILICALS	L-
• MANIP. ACCESS & FREE SWEPT VOL.	RMS/CRANE OPS ENVELOPE REQD TO POSITION S/C,P/L,SPARE AT WK STA	M+
• SHELTER VOLUMETRICS	EXT. SUB-STA SHELTER ∿8' x 7' x 5'	L+
• SPARES ACCESS	VOL.ADJACENT TO SUB-STATION & TRANSFER SWEPT VOL;UP TO 14.5 DIA x 16'	M-
• SIGNAL/POWER I/F's	CABLE RUNS,BREAKOUT I/F BOXES;UMBILICALS;SAFETY PROVISIONS	L-
• THERMAL I/F's	STA. RADIATOR ACCESS; INT. SUB-STATIONS (SUPPORT) REQUIRE LOW T-RAD	L-

SPACE STATION PROGRAMS

CONSTRUCTION & ASSEMBLY

AREAS	INFLUENCES	RATING (HML)
• RMS(S) SWEPT VOL	DOME (FROM 50' TO PROPOSED LARGE RMS UP TO 300')	H-
• TRACKED RMS SWEPT VOL.	DISTANCE OF TRACK PLUS POTENTIAL OVERLAPS	H-
• DOCKING/BERTHING SUPP.	BERTHING DEVICES WITH ARTICULATION (YAW/ROLL/PITCH)	M-
• CONSTRUCTION GROWTH AREA	MTG.I/F;FREE SWEPT VOL.;UP TO 1.2 x 4.6K FT ATTACHED	H
• LARGE STRUCT. DYNAMICS/ LOADS IMPACT	HZ SENSITIVE;MASS LIMITED;COUPLE/DE-COUPLE SENSITIVE	H
• LOGISTICS I/F	GENERALLY LIMITED TO 65K LBS & 14.5' DIA x 56' LONG	M
• MATERIAL STOWAGE	ENVIRON.SENSITIVE;LOCATION PROX.CRITICAL;HANDLING FEASIBILITY	M
• PIER & BEAM BUILD-UP	I/F MTG POINT;SIZE;DYNAMICS/LOADS;RMS/CRANE ACCESS;ALIGNMT.	M+
• TRACK ASSEMBLIES	CONSTR.TECH.;ALIGNMT.;TYPE;LOCATION;SUPPORT STRUCTURE	M+
• SHADOWING	IMPACT TO SA'S,RADIATOR,INSTR.LOS;VIEWING:ILLUMINATION	M+
• CONSTRUCTION SUPPORT	LOGISTICS;EVA;RMS &/OR CRANE;RCS COORD.;BUILDER AVAIL.	M
• CONSTRUCTION FREE SWEPT VOL.	CONSTR.ITEM;RMS/CRANE I/F;LOGISTICS/ITEM MANIPULATION	H-
• STAY-OUT AREAS	DOCKING PORTS;SA'S;RADIATORS;RCS BOOMS/JETS;INSTRVIEW LOC.	M+

SPACE STATION PROGRAMS

SAFETY

AREAS	INFLUENCES	RATING (HML)
• POWER	UP TO 8 kW AVER; 9-10 kW UP TO 1 HR 3 TIMES/DAY; 10-12 kW UP TO 1-2 MIN/HR	M+
• POINTING & CONTROL	DEAD BANK ±0.05(LOS);RATE DEG/SEC ±0.01(LIMITED);MICRO-G(10^{-4}G)	H
• THERMAL DISSIPATION	MAX UP TO TBD BTU OR TBD kWhr PER ATTACHED S/C	M
• ORBIT ALT. MAINTENANCE	TMS/OTV REQD.TO MAINTAIN S/C AT HIGHER ALT, VARIED INCLINATION	M
• P/L PWR SOURCE RECHARGE	AVAIL AT STA SERVICE UMBIL. I/F; UP TO 2 kWhr	M-
• LIQUID/PRESS. SOURCE	TANKAGE UP TO 60K LBS INITIAL;NO OF TANKS (UP TO 4)-CRYO/STORABLE	H
• LIQUID/PRESS. XFER SYS.	UMBIL/LINES;PRESSURANT;MULTI-FLOW RATES;SAFETY;MAINT.ACCESS	L+
• BERTHING/DOCKING PORT(S)	MULTIPLE (4 to 8);FULL ACCESS;I/F WITH UMBILICALS;STD SIZING	M+
• MECHANICAL MTG. I/Fs	MTG POINTS FOR WK STA,RACKS,EVA AIDS,POSITIONABLE PLATFORMS	M-
• CABLING I/Fs & RUNS	AVAIL AT DOCK.PORTS,PLATFMS,RACKS, HANGARS, SIG/PWR/COMM	L
• SOLAR SHADING	DEPLOY/RETRACT SHADES;RESPOSITIONABLE;UP TO 30' x 50'	L
• LOGISTICS ACCESS/STOWAGE	AVAIL AT WORK SITE; XPORTABLE VIA RMS/CRANE; PROTECTION; IV/EV	L+
• SPARES ACCESS/STOWAGE	PROTECTION;TRANSPORTABILITY;RESTRAINED;RMS/CRANE I/F;IV/EV	L+
• SIGNAL/POWER I/Fs	AVAIL AT WORK SITE; UNVAL I/F; SERVICE BOX; IV/EV	L

VULNERABILITY/HAZARDS

AREAS	INFLUENCES	RATING (HML)
• MICRO-METEORITE	ADDED 'SHIELDING'-DOUBLE BUMPER $\sim$0.02 & 0.01 AL (EXAMPLE)	L+
• SOLAR FLARE	AVER.LESS THAN 20% OF PRIMARY RAD DOSE;MAX FLARE(1956) REQUIRES 500 G/CM^2	M-
• DEBRIS	SCANING RADAR;BUMPER PROTECTION;MULTI-PURPOSE SCAVAGING VEH.	M-
• DOCKING OVERLOAD	MAX IMPACT $\sim$0.2 FT/SEC;HABITAT 'CLOSE-OUT';ADDED DOCK SYS. SAFETY FACTOR	M-
• COLLISION	CRIT.OF DOCK PORT LOCATION;EMERG.CREW RETREAT;S/C-SHUTTLE OPS APPROACH CONSTR.	M+
• PRESSURE LOSS	EMER.CREW RETREAT;$\sim$0.90 NO PUNCTURE PROB.;EMERGENCY RESCUE REQT.	M+
• REMOTE HANDLINC DAMAGE	RMS/CRANE MAX REACH(50'-100'); ORBITER RMS(50');TELEOP WITH ARMS $\sim$10'	M-
• PLUME IMPINGEMENT	ORBITER $\sim10^{-2}$ TO 10^{-6} DIRECT PRCS PRESSURE;EJECTA ENVELOPE ORB/OTV/TMS	M+
• SUN SHADOWING	DOCKING PORT(S) LOCATION;RADIATOR POSITION;RESULT IN S.A.SHADOW	H-
• POWER LOSS	SAFETY CRITICAL;BACK-UP SYSTEM;POSSIBLE CREW RESCUE/EARTH RETURN	M+
• THERMAL IMBALANCE	THERMAL OVERLOAD = REDUCED FUNCTIONS (SUPPORT); ADDED EQUIP/RADIATORS	M
• CONTAMINATION	DOCKING PORT(S) LOCATION;APPROACH/DEPART ENVELOPES;PLUME EJECTA	M+
• RADIATION	LEO (QUARTERLY): BONE MARROW 5CM DEPTH - 35REM;SKIN 0.1 MM DEPTH = 105 REM; LENS 3MM DEPTH = 52 REM; TESTES 3CM DEPTH = 18 REM. 60° ORBIT $\sim$20 TO 23 REM/24 HRS;90° MORE SEVERE SHIELDING RANGE: 28½° $\sim$0.1 G/CM^2 & 60° $\sim$0.3 G/CM^2	M

SPACE STATION PROGRAMS

ARTIFICIAL GRAVITY

AREAS	INFLUENCES	HML
• HARDWARE-ADDITIONS	VARIOUS: TETHERS;COUNTER WTS;HUBS;SPOKES;BOOMS;ATT.CONTROL	M+
• CONFIGURATION	LOCATION: DOCKING PARTS;SA'S;RADIATORS;ACS;TETHERS;HANGARS; TRACKS RMS/CRANE;PIERS/BEAMS;ANTENNAS/DISHES;TUNNELS;HAB/LABS	H
• LAYOUT	APPROACHES: TETHER,RING/SPOKE;RADIAL-HUB;DUMBELL; ROTATING TANGENTIAL	H+
• ARRANGEMENT	'ALIGNMENT' OF HABITATS/LABS/TUNNELS/HUBS;INTERNAL ARRANGEMENT OF VESSELS	M+
• SWEPT ENVELOPES	SHUTTLE-S/C APPROACH/DEPART ENVELOPES PLUMES;RMS/CRANE REACH;S.A.'s	M+
• PROPULSION & ATTITUDE CONTROL	DYNAMICS/LOADS/MASS;PROPELLANT;THRUSTER LOCATIONS/CMGS; PLUMES	M+
• GRAVITY INFLUENCE	CONTINUOUS VS INTERMITTENT; MICRO G's 0.5 TO 1.0; EXPER NEEDS; OPS CONSTRAINTS	M+
• RADIUS ARM OR TETHER	LENGTH: ARM$\sim$200';TETHER $\sim$ MANY MILES;TYPE OF RADIUS ROTATION	H
• DOCKING/BERTHING	ROTATION CONSTRAINT;HUB (DOCKING PORT);LIMITED PORTS;ACCESS	M+

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SPACE STATION PROGRAMS

ATTACHMENT 2
SUPPORTING DATA AND ANALYSIS REPORTS
VOLUME II

CONFIGURATION CONCEPTS EVALUATION

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SPACE STATION PROGRAMS

ATTACHMENT 2
SUPPORTING DATA AND ANALYSIS REPORTS
VOLUME II

CONFIGURATION CONCEPTS EVALUATION

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CONFIGURATION CONCEPTS EVALUATION

The facing page presents the results of evaluation of 11 of the 32 space station configuration developed in this study. Results for the evaluation of the other 21 configurations are given in Attachment 2 to this report.

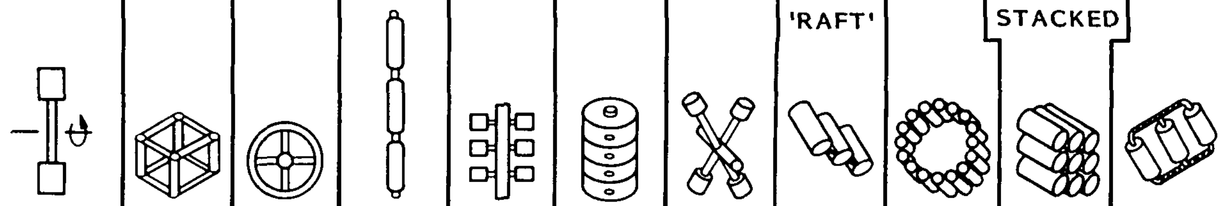
Each of the 32 concept configurations were subjected to a KTA evaluation to determine overall practicality, mission suitability, and utility. The evaluation criteria used was as follows:

1. Orbiter Considerations
   - No. of Orbiter launches
   - Config. fits cargo bay vol.
   - Adaptable to Orbiter support
2. Feasibility
   - Structural stability
   - Technical dev. practicality
   - Ease of on-orbit assembly
3. Flexibility
   - Permits large struct. assy.
   - Multiple docking ports & access
   - Adapatability to growth
   - Permits artificial g
   - Meets mission/operations needs
4. Programmatics
   - Permits existing hdwr. application
   - Cost sensitive & cost practical
5. Performance Capability
   - Meets mission needs
   - Allow 0 to partial g

Each concept was individually rated one against the other based on the above criteria. Scores were then summed for each configuration concept and the concepts rank ordered. Results of this evaluation are presented in the Architectural Concept Configuration Evaluation Summary chart following these charts.

SPACE STATION PROGRAMS

CONFIGURATION CONCEPTS EVALUATION



ELEMENT TYPES \ CONFIGURATION TYPES		DUMBBELL	INTERCONNECTED PIER MOUNT	RING/SPOKE MT.	LONGITUDINAL	HUB-TUNNEL MOUNT	STACKED	CLUSTER PAC: RADIAL HUB MT.	CLUSTER PAC: 'RAFT'	CLUSTER PAC: TANGEN-TIAL	CLUSTER PAC: STACKED	CLUSTER PAC: TIER STRONGBACK
ORB. I/F	• NO. OF ORBITER LAUNCHES	9	6	3	8	5	6	5	8	3	3	6
	• CONFIG. FITS BAY VOLUME	9	8	2	9	8	5	7	9	9	9	9
	• MEETS LAUNCH WT. LIMITS	9	4	2	7	4	6	5	7	1	1	6
	• ADAPTABLE TO ORB. SUPPORT	8	9	6	7	9	6	6	8	9	9	9
FEAS.	• STRUCTURAL STABILITY	2	6	8	2	6	9	4	8	8	9	7
	• TECH. DEV. PRACTICALITY	5	6	3	8	9	6	9	9	8	8	8
	• ASSY EASE ON-ORBIT	9	4	2	7	6	9	4	8	5	5	6
FLEX.	• PERMITS LG. STRUCT. ASSY	3	9	3	4	5	7	6	8	8	8	9
	• MULTI-DOCK PORTS & ACCESS	5	9	2	5	8	7	7	7	9	9	8
	• ADAPTABILITY TO GROWTH	6	8	1	2	7	9	2	9	7	9	8
PROC.	• COST	7	5	2	8	7	7	4	8	6	6	7
	• EXIST. HDWR. APPLICATION	3	2	1	2	2	1	2	2	2	2	2
NEW	• MEETS MISSION NEEDS	1	8	1	7	8	7	4	8	7	7	8
	• ALLOW O TO PARTIAL G	9	1	9	1	6	1	9	1	3	1	1
		85	85	45	77	89	89	72	100	85	79	94

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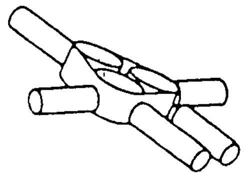
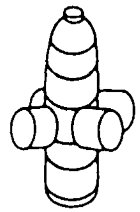
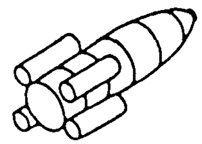
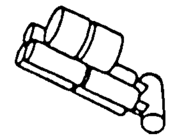
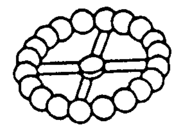
SPACE STATION PROGRAMS

CONFIGURATION CONCEPTS EVALUATION (Continued)

CONFIGURATION TYPES / ELEMENT TYPES	COMBINATIONS				BEADED
					
• NO. OF ORBITER LAUNCHES	2	6	4	2	1
• CONFIG. FITS BAY VOLUME	5	5	5	5	9
• MEETS LAUNCH WT. LIMITS	3	6	6	2	2
• ADAPTABLE TO ORBS. SUPPORT	9	9	8	7	6
• STRUCTURAL STABILITY	6	7	8	6	8
• TECH. DEV. PRACTICALITY	6	8	9	4	2
• ASSY EASE ON-ORBIT	5	7	6	3	2
• PERMITS LG. STRUCT. ASSY.	8	6	8	4	3
• MULTI-DOCK PORTS & ACCESS	9	9	8	8	2
• ADAPTABILITY TO GROWTH	5	6	5	6	1
• COST	6	8	7	3	1
• EXIST. HDWR. APPLICATION	2	7	6	2	1
• MEETS MISSION NEEDS	7	7	7	7	1
• ALLOW O TO PARTIAL G	5	4	5	1	9
COMBINATIONS BEADED	78	95	92	60	48

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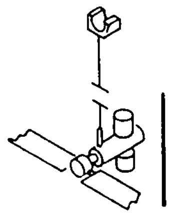
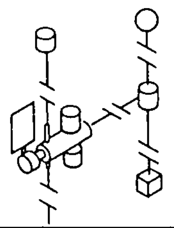
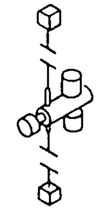
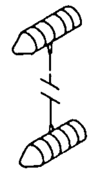
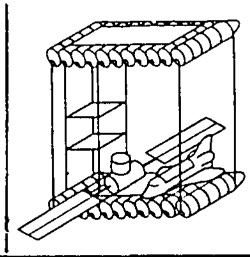
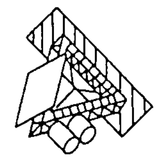
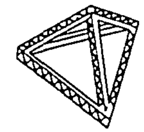
SPACE STATION PROGRAMS

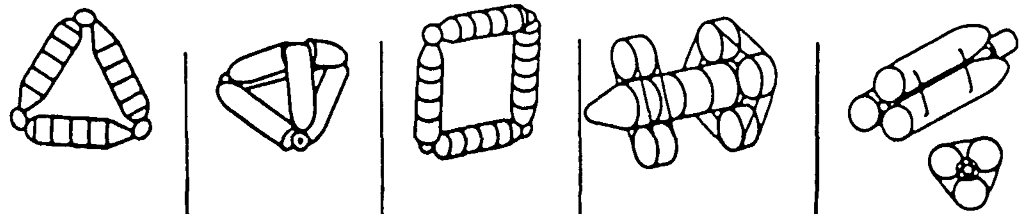
CONFIGURATION CONCEPTS EVALUATION (Continued)

CONFIGURATION TYPES / ELEMENT TYPES	TETHERED				RIGID TRUSS	TRIANGLE	PYRAMID
							
• NO. OF ORBITER LAUNCHES	7	6	6	9	1	7	6
• CONFIG. FITS BAY VOLUME	9	9	9	5	5	8	8
• MEETS LAUNCH WT. LIMITS	8	7	7	10	1	6	6
• ADAPTABLE TO ORB. SUPPORT	7	7	7	8	9	7	8
• STRUCTURAL STABILITY	6	6	6	9	7	8	9
• TECH. DEV. PRACTICALITY	7	7	7	7	2	7	7
• ASSY EASE ON-ORBIT	7	7	7	9	1	7	6
• PERMITS LG. STRUCT. ASSY.	5	4	4	5	8	5	6
• MULTI-DOCK PORTS & ACCESS	6	7	8	6	9	6	7
• ADAPTABILITY TO GROWTH	7	7	7	1	9	7	8
• COST	8	6	6	9	1	8	7
• EXIST. HDWR. APPLICATION	3	2	2	9	3	4	3
• MEETS MISSION NEEDS	9	9	9	7	7	8	8
• ALLOW 0 TO PARTIAL G	5	5	5	5	5	1	1
	94	89	90	99	68	89	90

Lockheed

SPACE STATION PROGRAMS

CONFIGURATION CONCEPTS EVALUATION (Continued)



CONFIGURATION TYPES / ELEMENT TYPES	EXT. TANK				
• NO. OF ORBITER LAUNCHES	5	3	4	8	7
• CONFIG. FITS BAY VOLUME	5	5	5	5	5
• MEETS LAUNCH WT. LIMITS	9	7	5	5	9
• ADAPTABLE TO ORB. SUPPORT	8	8	8	7	8
• STRUCTURAL STABILITY	7	8	5	6	9
• TECH. DEV. PRACTICALITY	7	7	6	7	8
• ASSY EASE ON-ORBIT	7	6	5	5	8
• PERMITS LG. STRUCT. ASSY.	8	8	8	9	7
• MULTI-DOCK PORTS & ACCESS	5	6	6	8	6
• ADAPTABILITY TO GROWTH	5	6	8	5	3
• COST	6	5	4	4	6
• EXIST. HDWR. APPLICATION	7	7	7	4	6
• MEETS MISSION NEEDS	8	8	7	8	7
• ALLOWS 0 TO PARTIAL G	1	1	1	3	2
	88	85	79	84	91

Lockheed

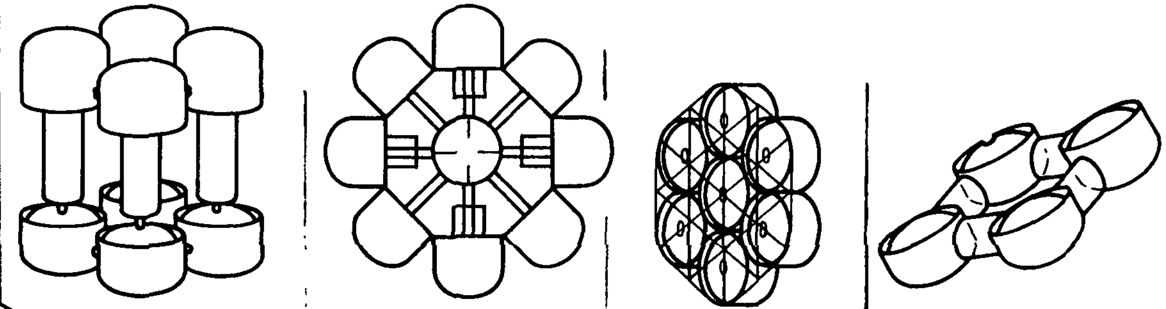
SPACE STATION PROGRAMS

CONFIGURATION CONCEPTS EVALUATION (Continued)

AFT CARGO CARRIER

CONFIGURATION TYPES

ELEMENT TYPES



ELEMENT TYPES				
• NO. OF ORBITER LAUNCHES	2	1	3	4
• CONFIG. FITS BAY VOLUME	5	5	5	5
• MEETS LAUNCH WT. LIMITS	2	2	2	3
• ADAPTABLE TO ORB. SUPPORT	8	8	8	8
• STRUCTURAL STABILITY	7	6	9	7
• TECH. DEV. PRACTICALITY	7	6	8	6
• ASSY EASE ON-ORBIT	5	4	6	6
• PERMITS LG. STRUCT. ASSY.	8	4	9	8
• MULTI-DOCK PORTS & ACCESS	8	9	9	8
• ADAPTABILITY TO GROWTH	9	9	9	7
• COST	3	3	4	4
• EXIST. HDWR. APPLICATION	2	2	1	2
• MEETS MISSION NEEDS	7	5	7	7
• ALLOW 0 TO PARTIAL G	1	7	5	1
	74	71	85	76

Lockheed

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SPACE STATION PROGRAMS

ATTACHMENT 2
SUPPORTING DATA AND ANALYSIS REPORTS VOLUME II

CADAM DRAWING FILE

Lockheed

CADAM DATA FILE ATTACHMENT 2 VOLUME 2

This appendix includes some selected layouts and sketches developed during the SSNAAO study on Lockheed computer graphics system, Cadam.

The various concepts have been grouped roughly into functional categories in this order.

- Formal data sheets
- Overall station concepts, including tethered
- Support and handling equipment
- Experiment carriers and free flyers
- Earth transportation
- Space station users
- Astronauts, shirtsleeve and suited
- OTVs and cryogenic tankage
- Modular elements
- Rescue vehicles
- Stored payloads, in the orbiter
- External tank concepts

LMSC-D889718

LMSC 24356

ATTACHT 2, VOL 2

APRIL 1983

Lockheed

SPACE STATION

NEEDS, ATTRIBUTES & ARCHITECTURAL

OPTIONS

CADAM DWG FILE OF

SYSTEMS & ELEMENTS

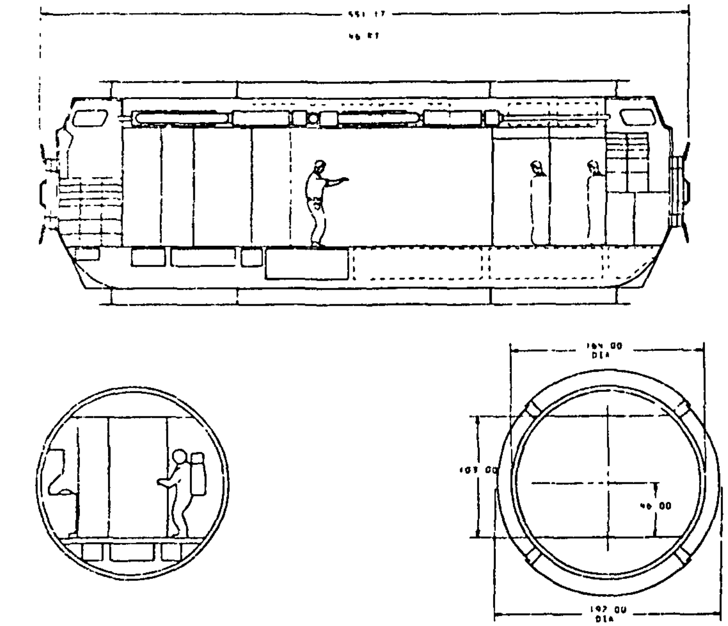
CADAM

Lockheed

STRUCTURE		7637
PRESSURE MEMBRANE (2219 AL)	4963	
RINGS FRAMES LONGRNS (2219 AL)	770	
TRUNNION FITTINGS (TI)	205	
HATCHES DOORS & LATCHES	479	
BEAMS WALLS (AL)	288	
FLOORS (HONEYCOMB)	196	
DOCKING MECHANISMS	136	
BERTHING PORTS (COMPLEX MECH S)	136	
THERMAL CONTROL		3014
RADIATOR SKIN (AL)	1437	
RADIATOR TUBES (AL EXTRN)	206	
PEDESTALS (AL)	420	
STANDOFF BRACKETRY (AL)	200	
MULTI LAYER INSULATION (70 LAYERS MYLAR)	88	
COLD PLATES (AL)	196	
FREON LOOP PUMPS/FILTERS/VALVES/ HEATERS CONTROLS	181	
FREON COOLANT	348	
ORDNANCE		32
32 PIN PULLERS	32	
ELECTRICAL POWER		665
WIRING	25	
HARNESSES	400	
CONN S SWITCHES ETC	50	
INTERIOR LIGHTING	40	
EMER BATTERY	50	
CM & C BACK-UP COMPUTER	100	
TRACKING & COMMAND		275
RF EQUIPMENT		167
SIGNAL PROC	22	
DIGITAL PROC	22	
SWITCHING UNIT	20	
MODULE & PREAMP	40	
GPS RCVR & PROC	23	
EVA RECVR & XMTR	20	
RADIO PROCESSOR	20	
INTRA-SOC VOICE		30
VOICE TERMINALS	10	
C & W EQUIPT	20	
C & T SUPPORT		78
TV CAMERA	20	
DIGITAL PROCESSOR	23	
HARNESSES	35	
DATA MANAGEMENT		568
DTS & CON PANEL	108	
CRTS	120	
KEYBOARDS & DISPLAYS	50	
REMOTE TERMINAL	120	
COMPUTERS (6)	120	
WIRING & BUSSING	50	
INSTRUMENTATION (NON-DEDICATED)		100
CREW ACCOMMODATIONS		853
DINING TABLE	41	
RECREATION	100	
HEALTH MAINTENANCE	200	
SLEEP RESTRAINTS	4	
WRITING DESK	41	
SIDEWALL LINER (LIKE AIRLINER)	122	
CEILING LINER (LIKE AIRLINER)	40	
PARTITIONS (LIKE AIRLINER)	159	
PERSONAL STOWAGE	40	
FOLDING DOORS	76	
MISC	23	
EC/LSS		1359
CONTROLS & DISPLAYS	34	
HUM CONT PACK	45	
THERMO REGENERATOR	14	
CO2 CONT PACKAGE	54	
TRACE CONTAM CONT	49	
WATER PROC EVAP	376	
HOT/COLD WATER	23	
WATER QUAL MON	27	
POTABLE WATER	69	
WASTE WATER STORAGE	69	
EMER WATER STORAGE	193	
THERMAL VENT	78	
EMU RECHGE STA	27	
FOOD FREEZER	27	
WASTE COLL SYS	41	
HAND WASH	11	
SHOWER	54	
CLOTHES WASHER	41	
TRASH COMPACT	18	
FOOD REFRIGERATOR	45	
DISHWASHER	41	
OVEN	23	
MISSION EQUIPMENT		3779
EVA SUITS PERSONAL EFFECTS MANUALS UTENSILS ETC	1155	
CONSUMABLES ATMOSPHERE SPARES,FOOD	1657	
SUPPLIES HOUSEKEEPING HYGIENE, COMMODE ECLS/EVA SUPPLIES	967	
MECHANISMS		136
UNIVERSAL BERTH PORTS	136	

TITLE SOC HABITAT — ENGINEERING DATA SHEET NO 55,45 SH 2

Lockheed



FOR MORE DETAILS SEE DWG NO SS 34

WEIGHT SUMMARY

STRUCTURE	7637
MECHANISMS	136
THERMAL CONTROL	3014
ELEC POWER	665
TRACKING & COMM	275
RF EQ	167
INTRA SOC VOICE	30
C & T SUPPT	78
DATA MAN	568
CREW ACCOM	853
EC/LSS	1359
CONSUMABLES	1653
SUPPLIES	967
GROWTH	7226
TOTAL	21740

SEE SHT 2 FOR DETAILS (47028 LBS)

POWER REQUIRMENTS

PERFORMANCE

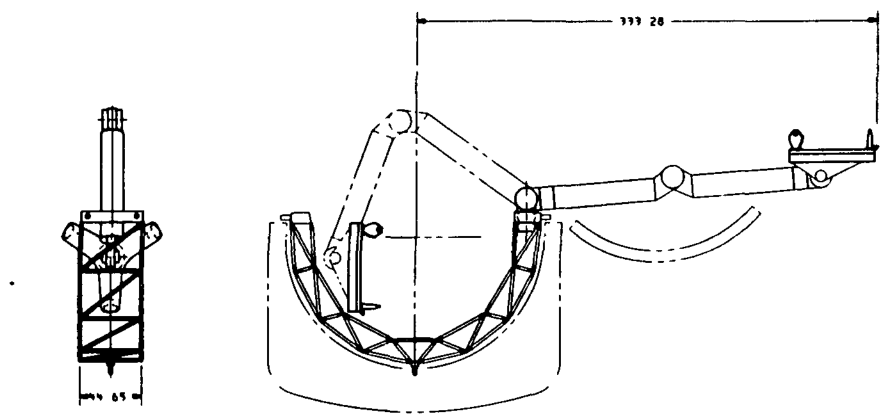
GENERAL DESCRIPTION

4 MAN PRIMARY LIVING & WORKING AREAS FOR SOC CREW

PROVISIONS FOR HOUSING 8 CREWMEN IN A DEGRADED EMERGENCY MODE

IS CONNECTED TO THE SERVICE MODULE & DOCKING TUNNEL VIA BERTHING PORTS

SOURCE	SOC FINAL REPORT 7/8 VOL 7	TITLE	LOCKHEED MISSILES & SPACE COMPANY INC
AUTHOR	G R WOODCOCK ET AL BOEING	JSC/BOEING 4 MAN HABITAT	NASA SPACE STATION NEEDS, ATTRIBUTES & ARCHITECTURAL OPTIONS STUDY
STATUS	STUDY		PREPARED P GARDNER
OTHER REFS	VOL 1 2		ENGINEERING DATA SHEET NO
USAGE	MAINLY LIVING SPACE		55,45
DATE	2000		



FOR TYPICAL APPLICATIONS SEE DWG # SS.41 & SS.42

WEIGHT SUMMARY KG

FRAME STRUCTURE	983
CROSS BEAM	
MOUNTING	68
MOTORS	51
ARM	275
GEARS & MOTOR	475
CONTROLS/ PWR DISTR	109
TOTAL	1961
	(2994 LBS)

POWER REQUIRMENTS

PERFORMANCE

JOINT MOTIONS

SHOULDER YAW	+180°	-180°
SHOULDER PITCH	+ 60°	- 90°
ELBOW PITCH	+140°	- 45°
WRIST PITCH	+130°	-130°
WRIST ROLL	+180°	-180°

GENERAL DESCRIPTION

PROVIDES A WIDE RANGE OF ADJUSTABLE WORK STATIONS
BOTH INBOARD & OUTBOARD OFTHE ORBITER CARGO BAY
CONTROL IS FROM A PANEL IN THE MDF AFT FLT DECK
ALSO USED IN DOCKING & BERTHING OPERATIONS
BERTHING.MOBILITY,TILT TABLE & EVA WORKPLACE MODULES CAN BE ATTACHED

SOURCE	SS WORKSHOP JSC 8/82
AUTHOR	C J GOODWIN GRUMMAN
STATUS	POST PHASE I
OTHER REFS	AXAF STUDY 4/82
USAGE	SPACE EQ HANDLING
IOC DATE	1986

TITLE

HANDLING & POSITIONING AID

(HPA)

LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

NASA SPACE STATION NEEDS ATTRIBUTES & ARCHITECTURAL OPTIONS STUDY NAS-W-3684

PREPARED D GARDNER DATE 9/9/82

ENGINEERING DATA SHEET NO

SS.49

LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

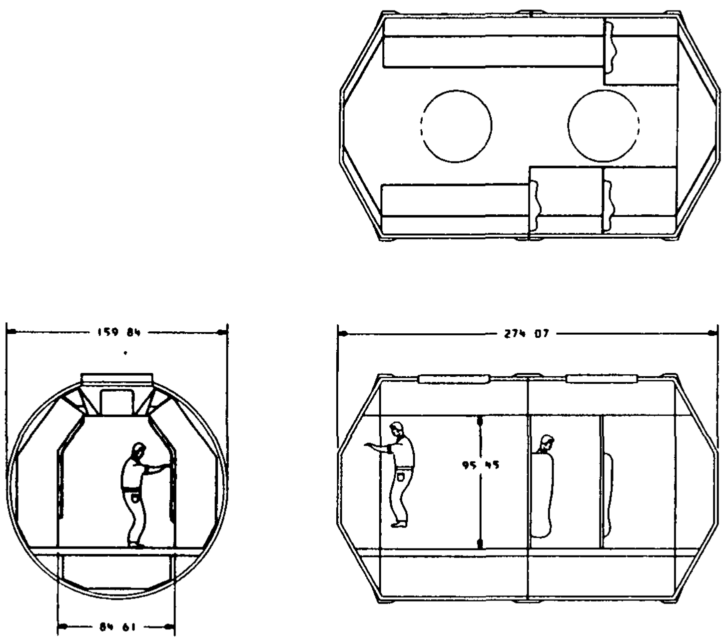
#2 DATA SHEET FORMAT

DWG D GARDNER DATE 8/25/82

DWG & MODEL NO SS.49 REV

SCALE SH

A



FOR MORE DETAIL SEE DWG NO SS.47

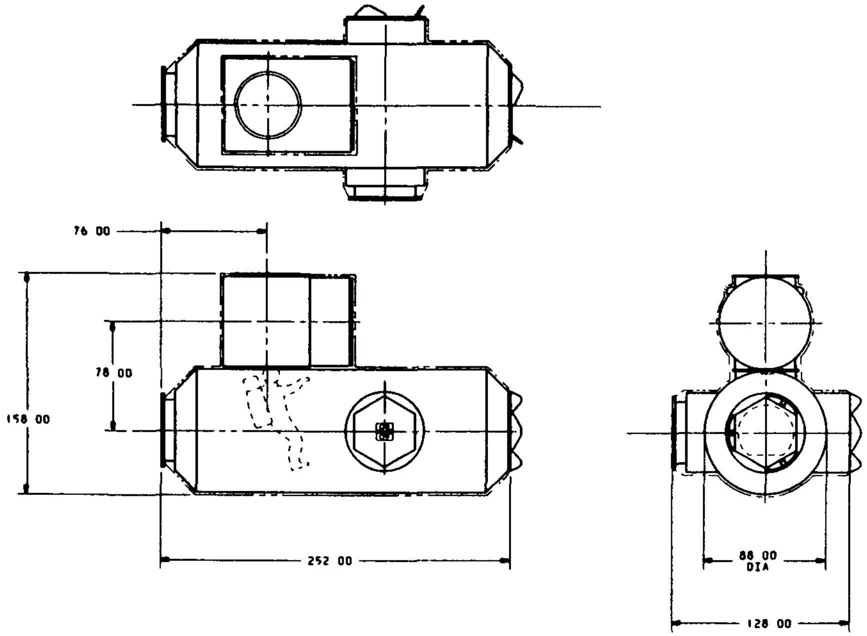
WEIGHT SUMMARY	POWER REQUIRMENTS PERFORMANCE

GENERAL DESCRIPTION

SOURCE	MDC REPORT #MDCG9712 8/81	TITLE	LOCKHEED MISSILES & SPACE COMPANY INC A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION SUNNYVALE CALIFORNIA
AUTHOR	F C.RUNGE ET AL MACDAC	MACDAC/MSFC HABITAT BASED ON ESA SPACELAB SHELL	NASA SPACE STATION NEEDS, ATTRIBUTES & ARCHITECTURAL OPTIONS STUDY NAS-W-7604
STATUS	STUDY		PREPARED D.GARDNER DATE 9/1/82
OTHER REFS	MSFC SASP STUDIES		ENGINEERING DATA SHEET NO
USAGE	LIVING QUARTERS		SS.50
IOC DATE	1990 ?		

BASED ON MACDAC SASP
IST INTERIM BRIEFING
MDC G9712 AUG 1981

DATA SHEET	
LOCKHEED MISSILES & SPACE COMPANY INC A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION SUNNYVALE CALIFORNIA	
MSFC/MACDAC HABITAT (USES ESA SPACELAB SHELL)	A
DWN D GARDNER DATE 9/10/82	
DWG & MODEL NO SS.50	REV
SCALE	SH



WEIGHT SUMMARY

POWER REQUIRMENTS

PERFORMANCE

GENERAL DESCRIPTION

SOURCE	MDC REPORT #MDCG9712 8/81	TITLE	LOCKHEED MISSILES & SPACE COMPANY, INC A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION SUNNYVALE CALIFORNIA
AUTHOR	F C RUNGE ET AL MACDAC	AIRLOCK/ADAPTER	NASA SPACE STATION NEEDS, ATTRIBUTES & ARCHITECTURAL OPTIONS STUDY
STATUS	STUDY	MSFC/MDC	PREPARED D GARDNER
OTHER REFS	MSFC SASP STUDIES		ENGINEERING DATA SHEET NO
USAGE	CREW & EQ TRANSFER		55,52
IOC DATE	1990 ?		

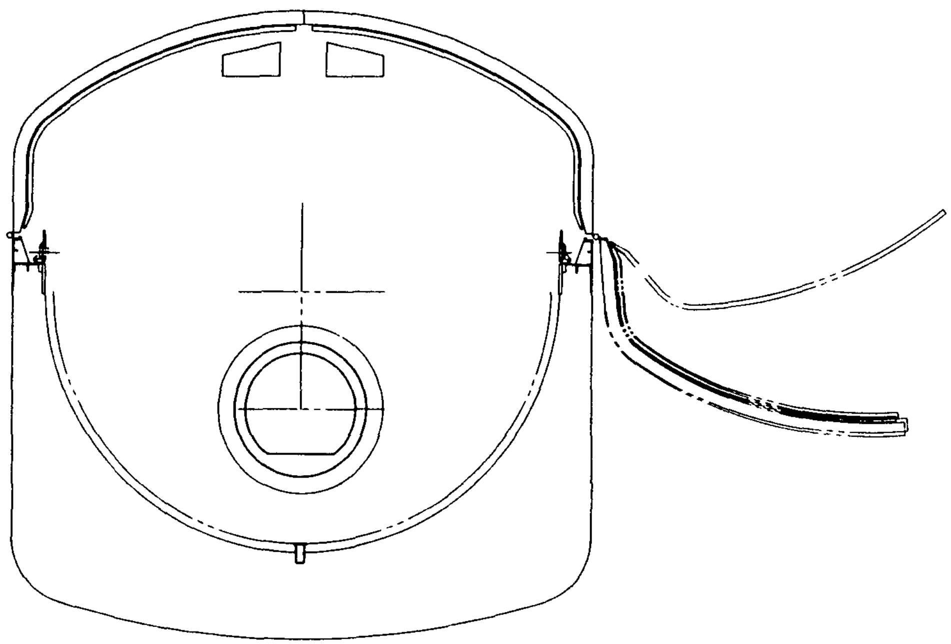
BASED ON MACDAC SASP
IST INTERIM BRIEFING
MDC G9712 AUG 1981

LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

MSFC/MACDAC AIRLOCK/ADAPTER

DWG & MODEL NO
55.52

SCALE



WEIGHT SUMMARY

POWER REQUIRMENTS

PERFORMANCE

GENERAL DESCRIPTION

DOOR & RADIATOR OPEN THRU 175 5° MAX
DOOR SECURED AT 174 75°
RADIATOR OPENS UPWARD 36 062° MAX
DOOR FRAMES ARE 4 75 DEEP   RADIATOR IS 1 75 DEEP
GAP BETWEEN RADIATOR & FRAME IS 0 50 IN

SOURCE RI MASTER DIMS SPEC V70-97-204 AUTHOR STATUS OTHER REFS USAGE IOC DATE	TITLE ORBITER PAYLOAD BAY DOOR & RADIATOR GEOMETRY	LOCKHEED MISSILES & SPACE COMPANY, INC A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION SUNNYVALE CALIFORNIA NASA SPACE STATION NEEDS ATTRIBUTES & ARCHITECTURAL OPTIONS STUDY NAS-W-9684 PREPARED D.GARDNER DATE 9/6/82 ENGINEERING DATA SHEET NO 55,55

LOCKHEED MISSILES & SPACE COMPANY, INC A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION SUNNYVALE CALIFORNIA	
ORBITER RADIATOR GEOMETRY	
DWN D GARDNER DATE 9/6/82	
DWG & MODEL NO 55.55	REV
SCALE	SH

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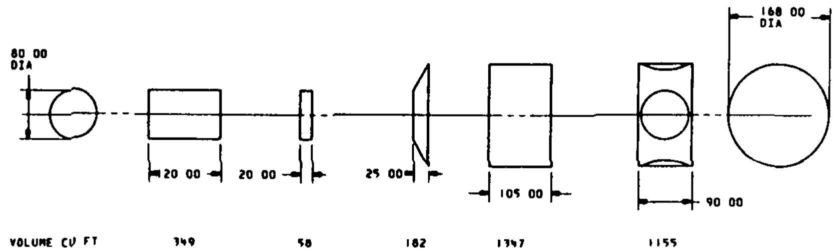
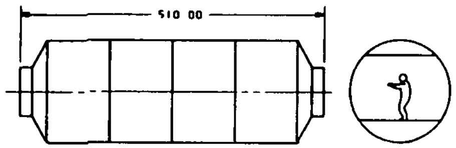
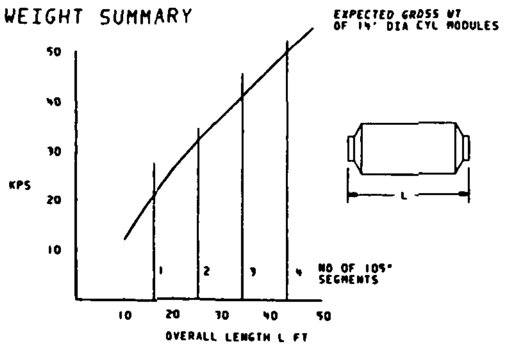




TYPICAL HABITATION MODULE UTILIZING STRUCTURAL MODULES

WEIGHT SUMMARY



POWER REQUIRMENTS

PERFORMANCE

GENERAL DESCRIPTION

SOURCE JSC MNGMT STATUS MTG 9/81 S-81-11858
AUTHOR A LOUVIERE/C COVINGTON ET AL
STATUS STUDY
OTHER REFS BOEING RPT D180-26715-1, D180-26495-3
USAGE SS BUILD UP
IOC DATE 1990

TITLE
SOC STRUCTURAL BUILDING BLOCKS
JSC/BOEING

LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

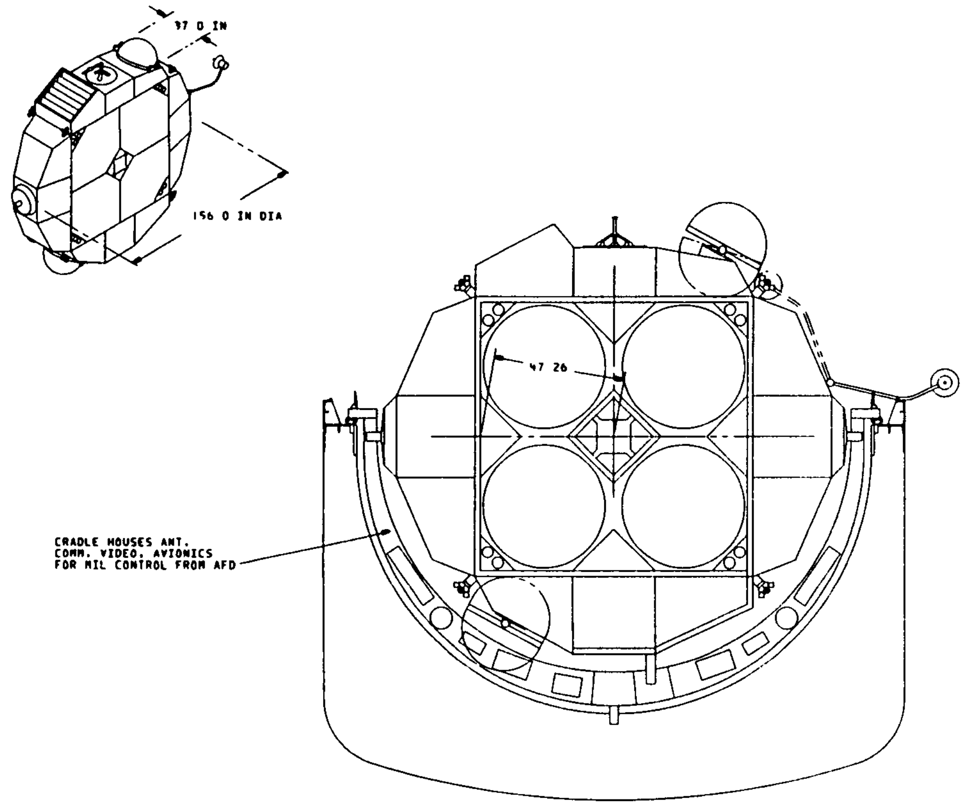
NASA SPACE STATION NEEDS, ATTRIBUTES & ARCHITECTURAL OPTIONS STUDY NAS-8-36xx

PREPARED D GARDNER DATE 9/10/82
ENGINEERING DATA SHEET NO
SS.58

DATA SHEET
LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

JSC CONCEPTS B & C
BUILDING BLOCKS

DWN D GARDNER DATE 9/10/82
DWG & MODEL NO
SS.58
REV
SCALE
SH



WEIGHT SUMMARY

STRUCTURE (WELDED AL)	612	
AVIONICS	388	
POWER	171	
THERMAL	105	
RCS	123	
MAIN	1034	
CONTINGENCY	112	
PROPELLANT MAIN & RCS (TI TANKS)	5000	
SUBTOTAL	7545	(PLACEMENT)
DOCKING KIT	281	
TOTAL	7826	(PLACEMENT & RETRIEVAL)
	(3522 KG)	

POWER REQUIRMENTS

PERFORMANCE

CAN ENHANCE STS PAYLOAD CAPABILITY

PROVIDE PLANE CHANGE CPABILITY

SEE SATELLITE SERVICES WORKSHOP REPORT 6/82
VOL I PG 95 ETC

GENERAL DESCRIPTION

TMS IS A MINI-TUG/UPPER STAGE

OPERATING OUT OF THE ORBITER.IT MAY BE CONTROLLED
FROM THE ORBITER AFT FLT DECK OR FROM THE GROUND

TYPICAL MISSIONS PAYLOAD PLACEMENT/RETRIEVAL SERVICING
MODULE EXCHANGE, REFUELING, VIEWING, SPACE SYS ASSEMBLY

SOURCE VOUGHT REPORT 5/82
AUTHOR ?
STATUS STUDY
OTHER REFS SAT SERV WKSHOP VOL I 6/82
USAGE SMALL OTV (EQ HANDLING/PLACING)
IOC DATE 1987

TITLE

TELEOPERATOR MANEUVERING SYSTEM

VOUGHT CORP

LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

NASA SPACE STATION NEEDS, ATTRIBUTES & ARCHITECTURAL OPTIONS STUDY NAS-W-3684

PREPARED DATE

ENGINEERING DATA SHEET NO
55.57

LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

TMS DATA SHT

DWN DATE

DWG & MODEL NO
55.57

REV

SCALE SH

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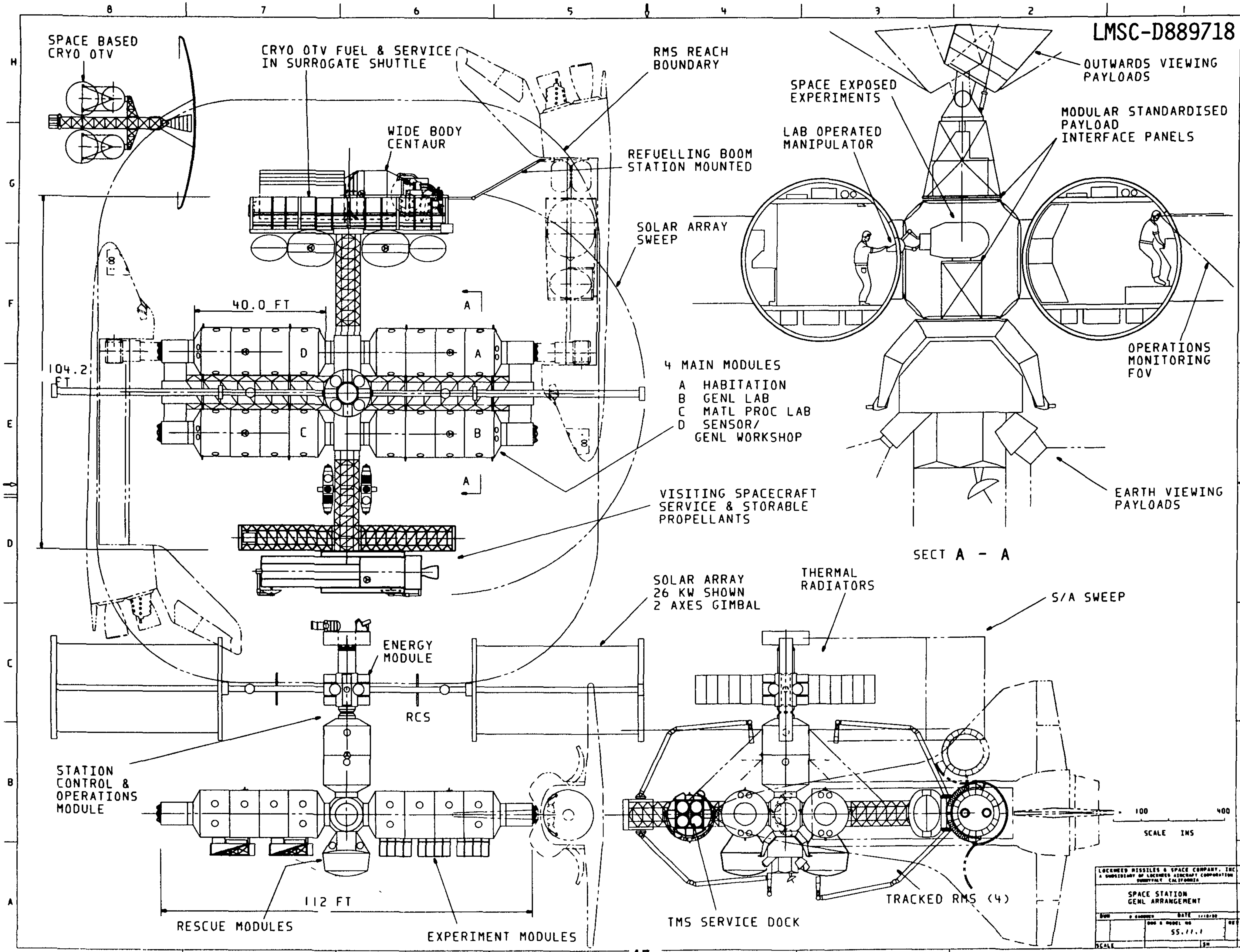
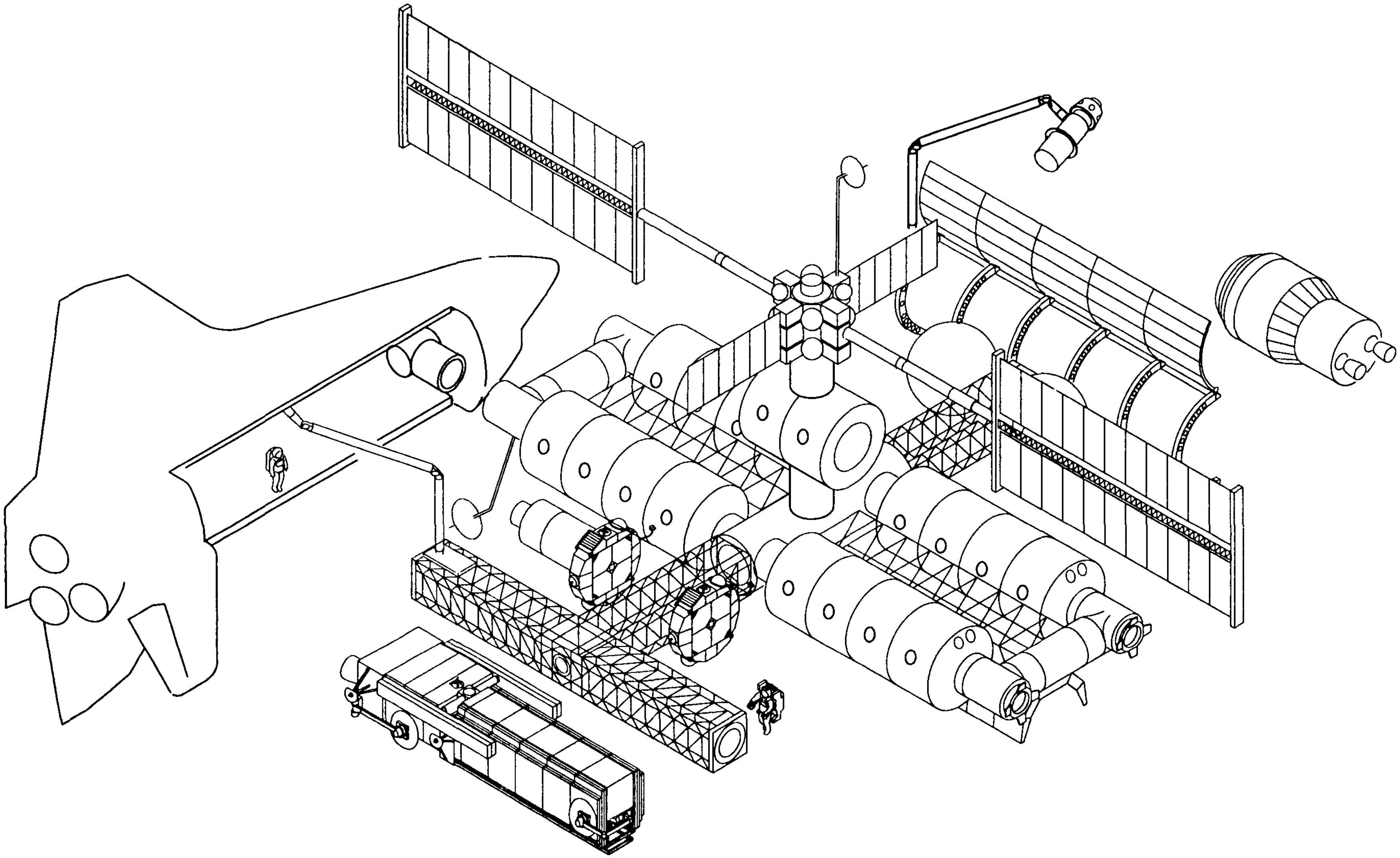
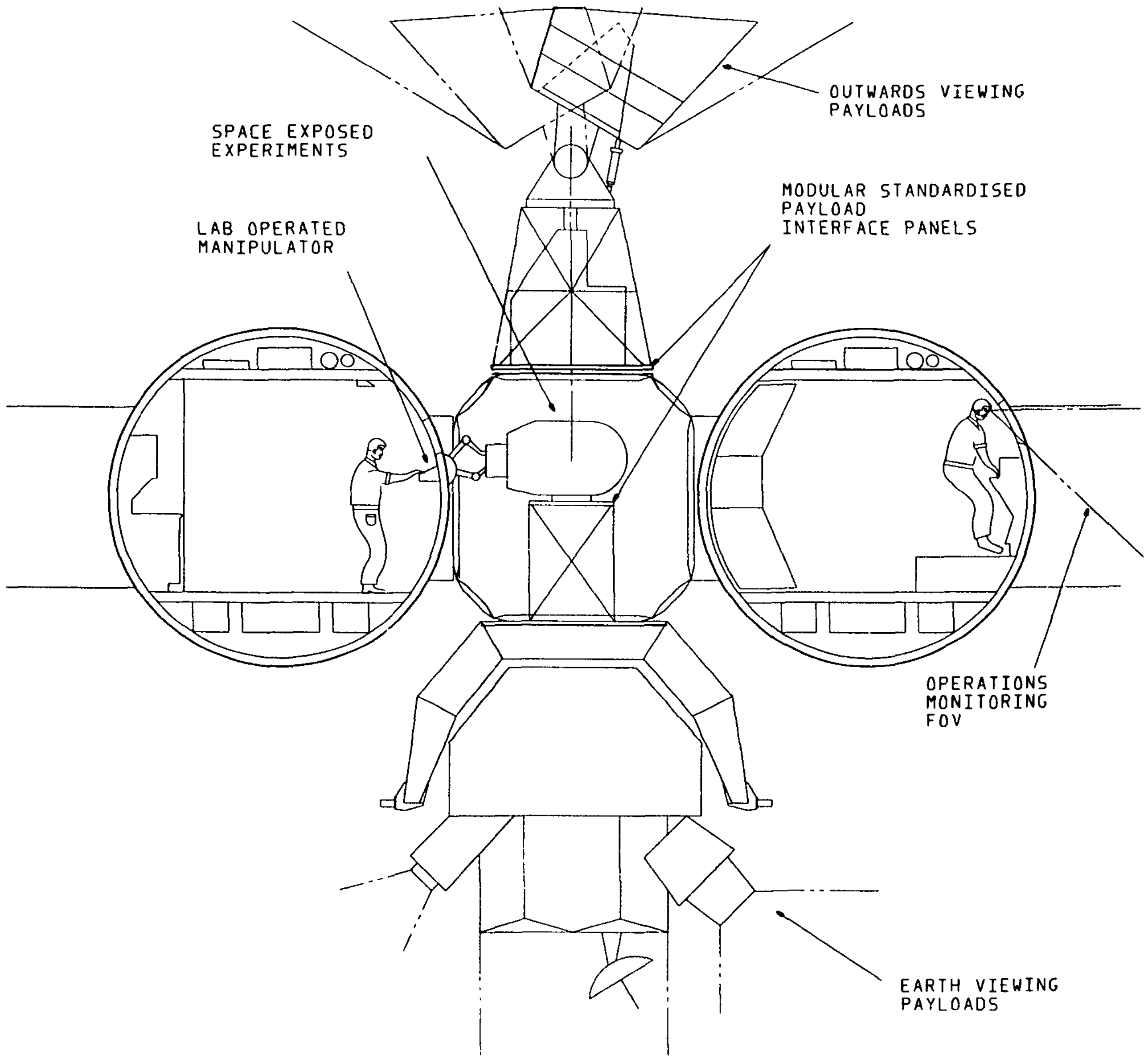

SPACE BASED
CRYO OTV
CRYO OTV FUEL & SERVICE
IN SURROGATE SHUTTLE
RMS REACH
BOUNDARY
WIDE BODY
CENTAUR
REFUELLING BOOM
STATION MOUNTED
SOLAR ARRAY
SWEEP
40.0 FT
104.2
FT
A
D
C
B
4 MAIN MODULES
A HABITATION
B GENL LAB
C MATL PROC LAB
D SENSOR/
GENL WORKSHOP
VISITING SPACECRAFT
SERVICE & STORABLE
PROPELLANTS
OUTWARDS VIEWING
PAYLOADS
SPACE EXPOSED
EXPERIMENTS
MODULAR STANDARDISED
PAYLOAD
INTERFACE PANELS
LAB OPERATED
MANIPULATOR
OPERATIONS
MONITORING
FOV
EARTH VIEWING
PAYLOADS
SECT A - A
SOLAR ARRAY
26 KW SHOWN
2 AXES GIMBAL
THERMAL
RADIATORS
S/A SWEEP
ENERGY
MODULE
RCS
STATION
CONTROL &
OPERATIONS
MODULE
112 FT
RESCUE MODULES
EXPERIMENT MODULES
TMS SERVICE DOCK
TRACKED RMS (4)
100
400
SCALE INS
LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA
SPACE STATION
GENL ARRANGEMENT
DATE
DWG & MODEL NO
55.11.1
SCALE
SH



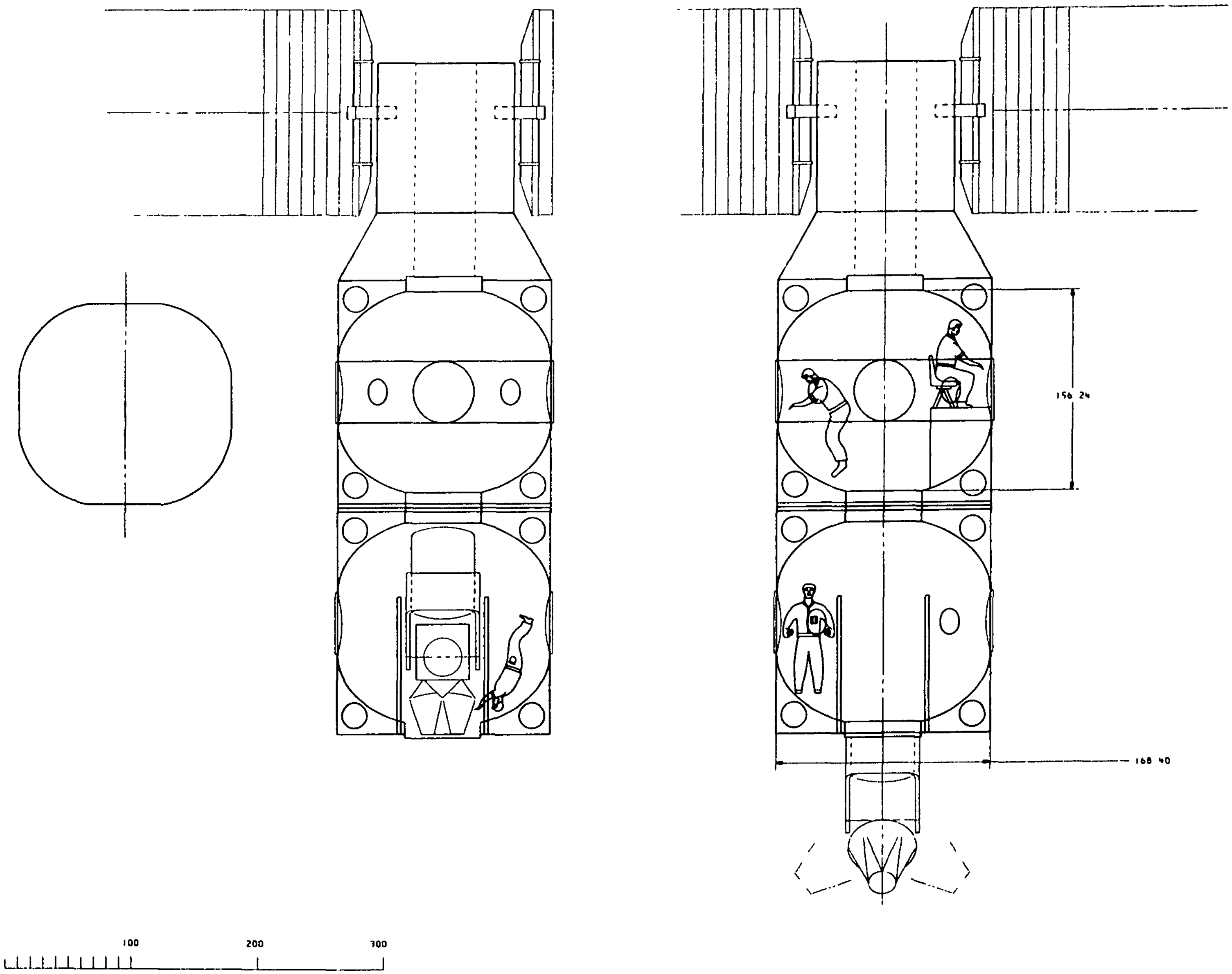
LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

REFERENCE STATION
WITH HORIZONTAL TOP MODULE

DWN		DATE	
		DWG & MODEL NO 55.14.1	REV
SCALE			SH



LOCKHEED MISSILES & SPACE COMPANY, INC
SS CROSS SECTION
DWG & MODEL NO SS.14.7
SCALE



LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

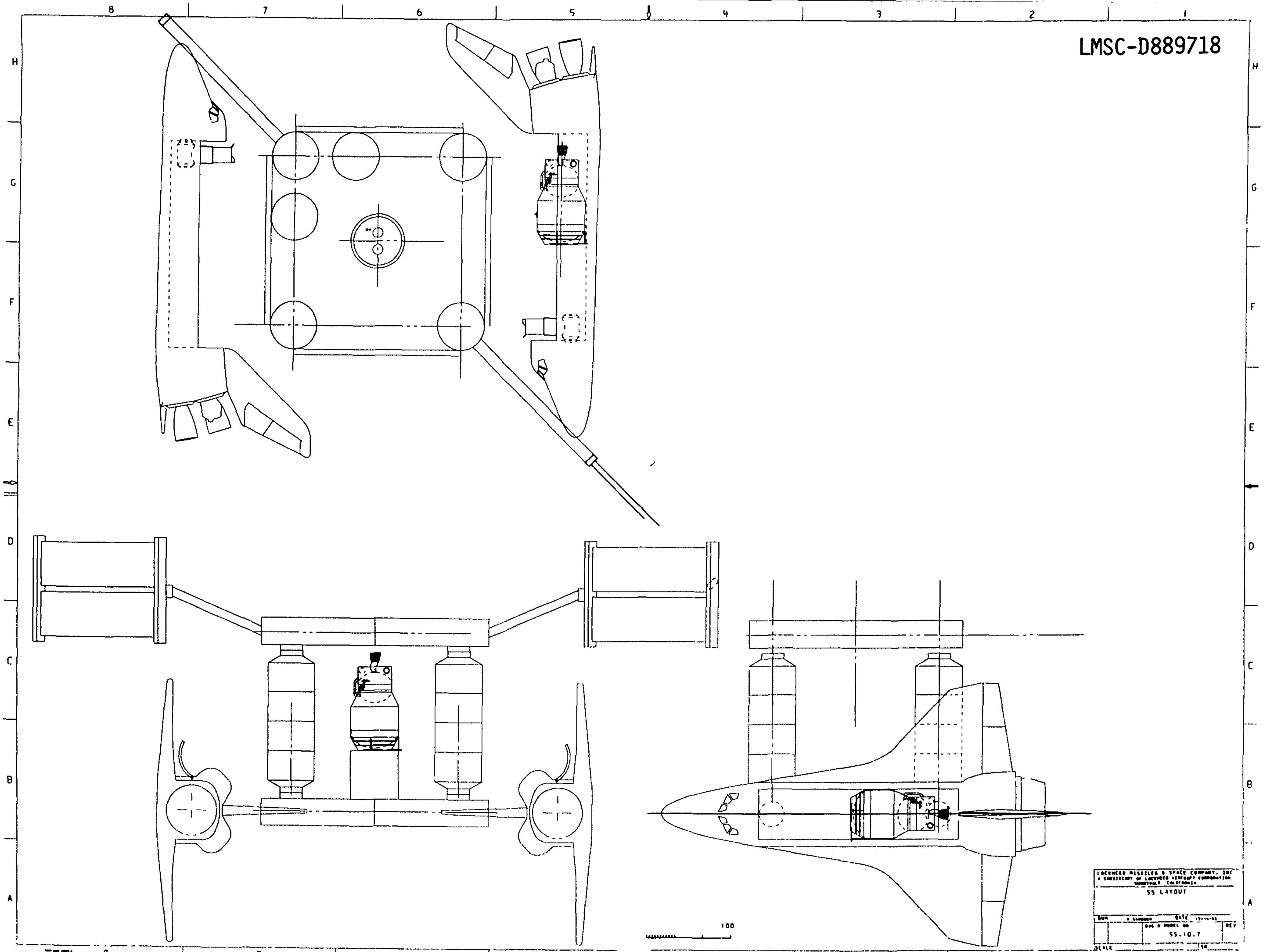
TYP DEVEL/MAINT CONCEPT

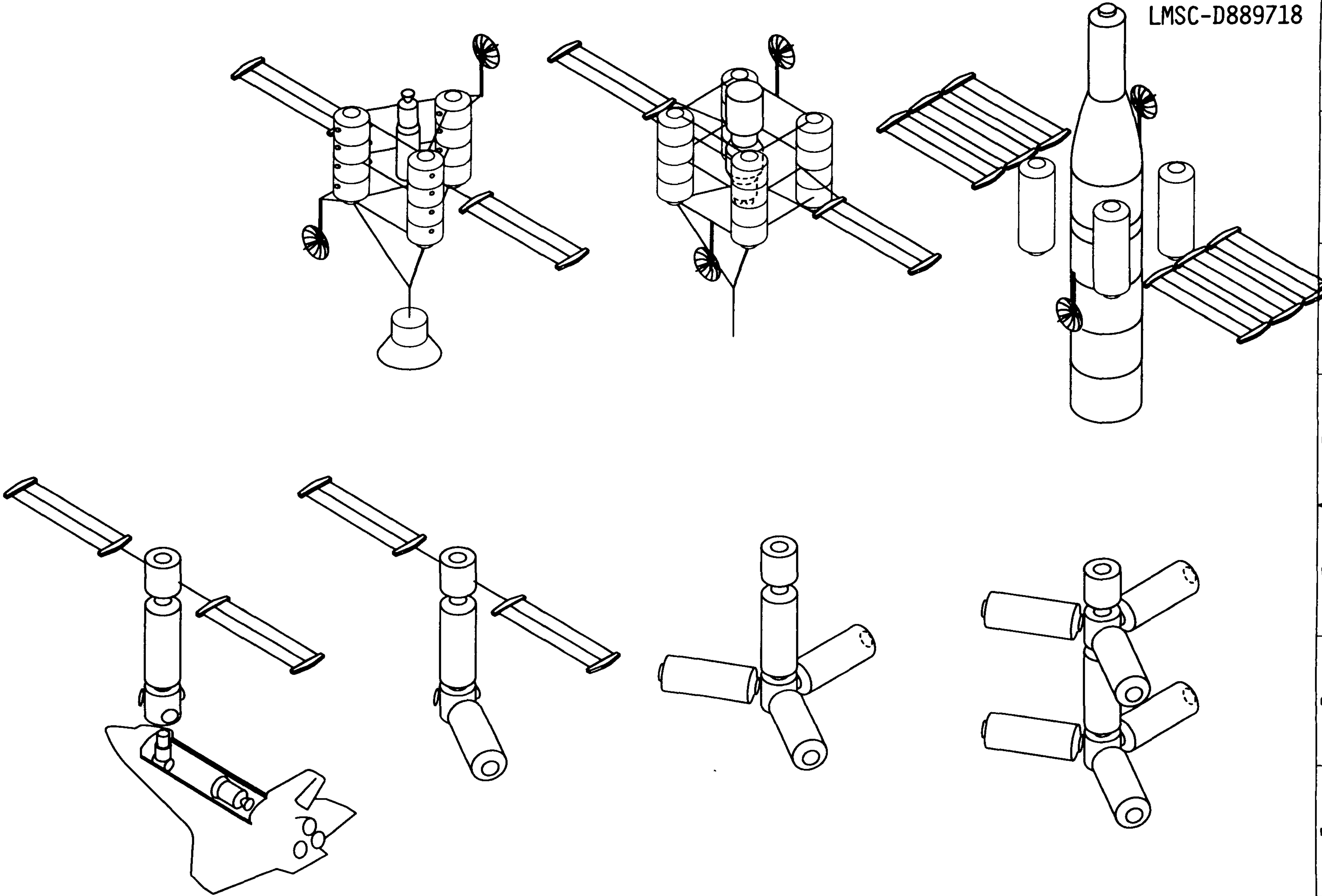
DWN D GARDNER DATE

DWG & MODEL NO SS.66

REV

SCALE

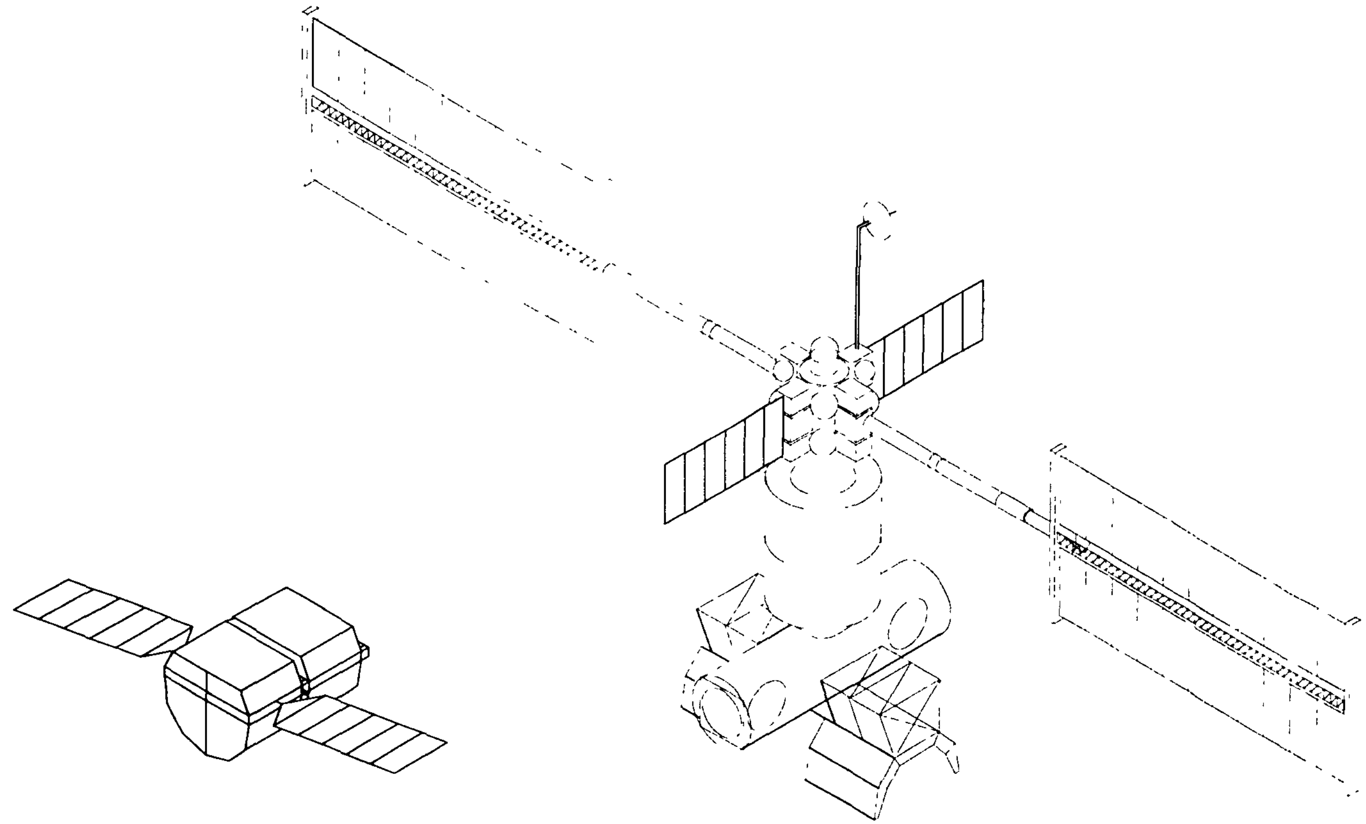

100
LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA
SS LAYOUT
DWG
DATE
DWG & MODEL NO
SS.10.7
REV
SCALE



LOCKHEED MISSILES & SPACE COMPANY, INC

LMSC SPACE STATION
CONCEPTS

55.59



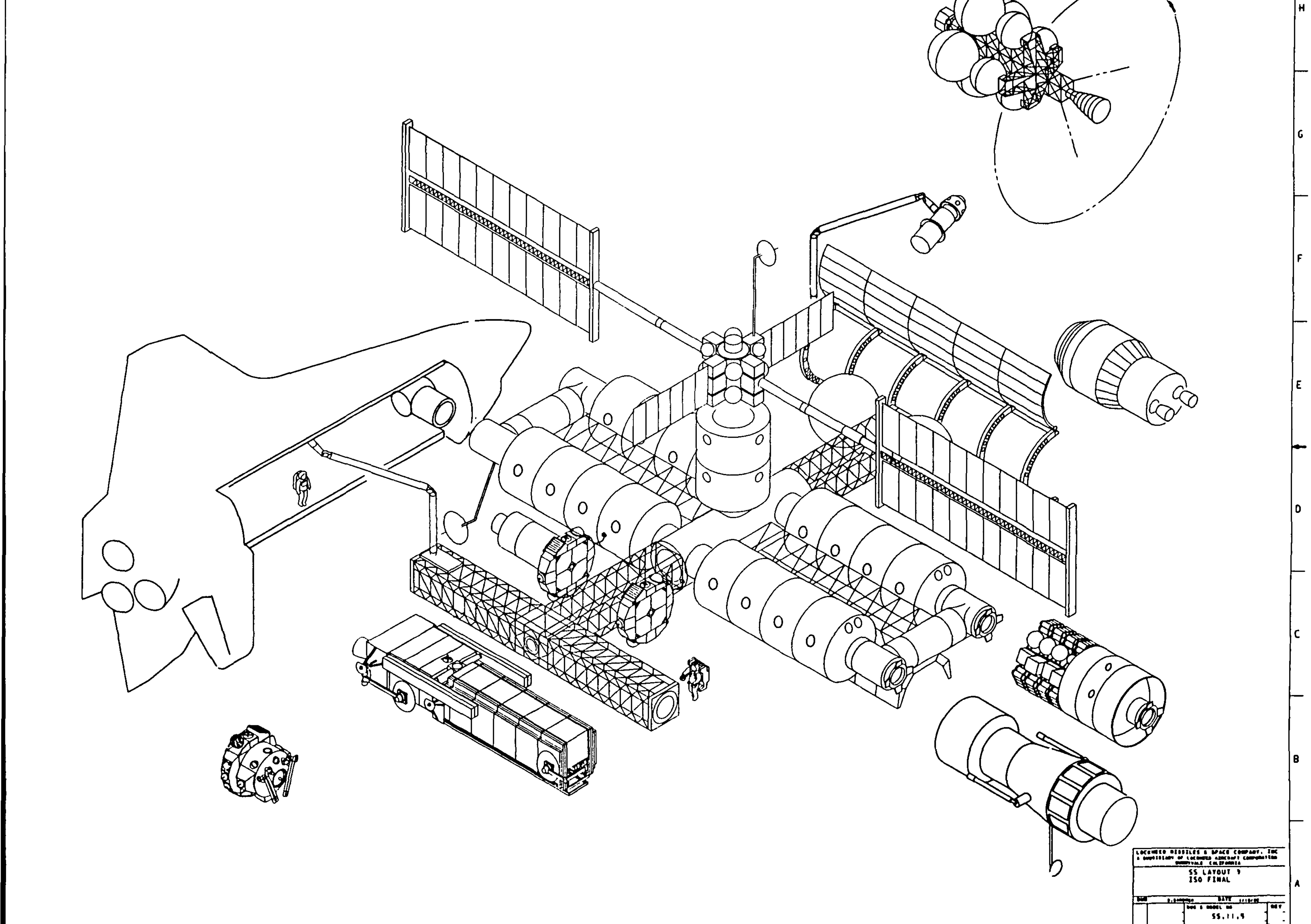
SS LAYOUT 3
MINIMUM CONCEPT

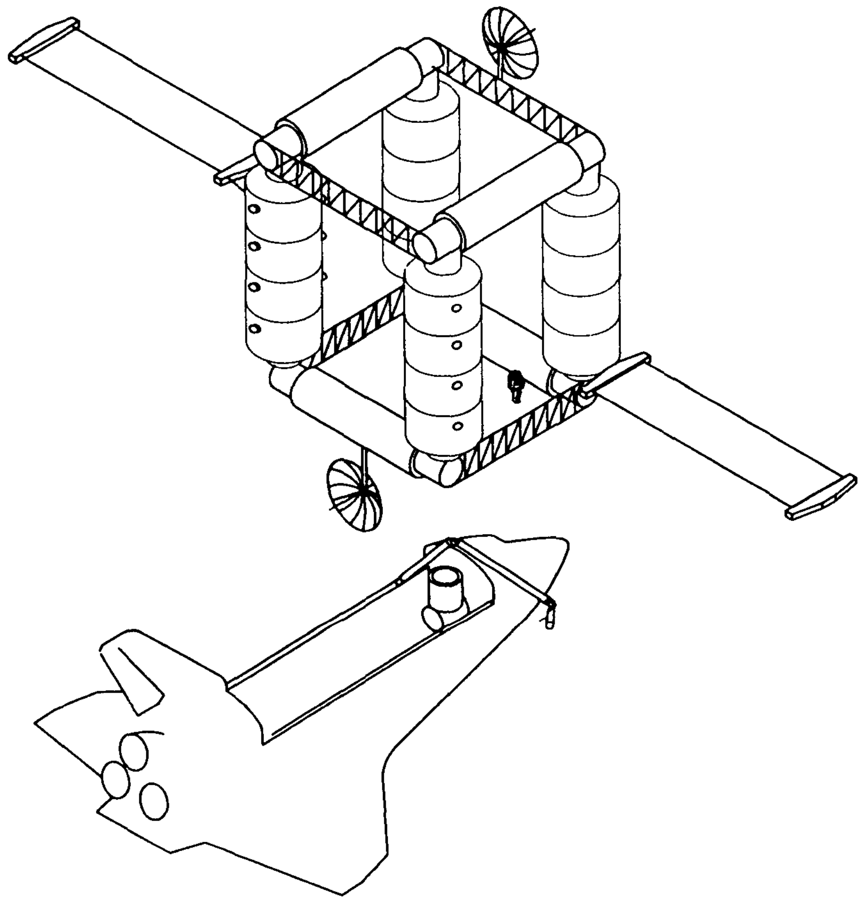
DATE

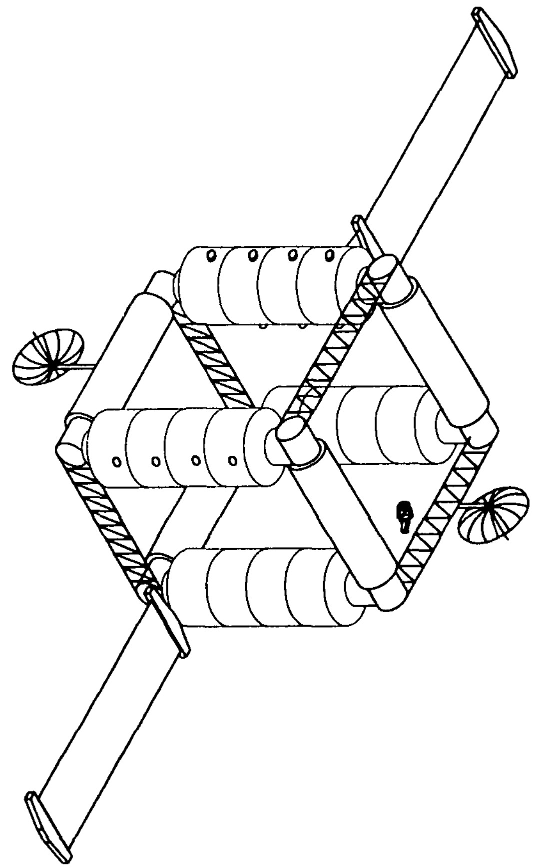
SS 12 5

SCALE

LMSC-D889718



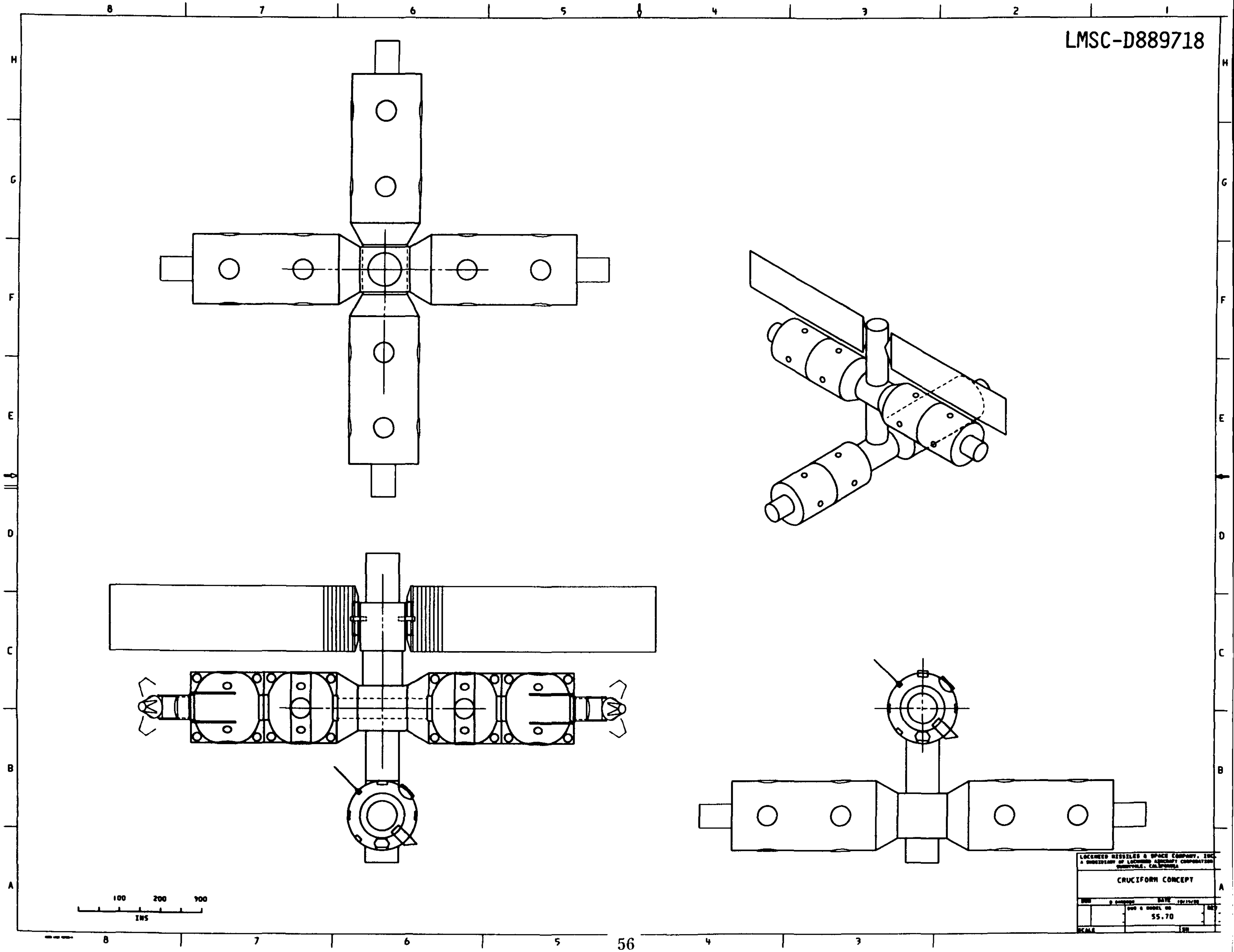


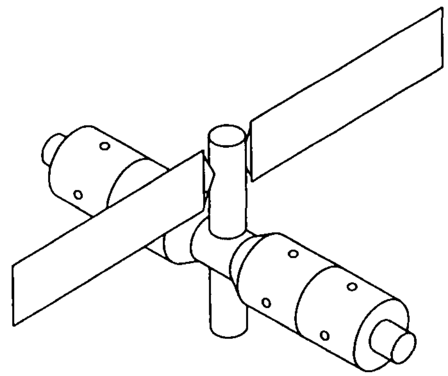


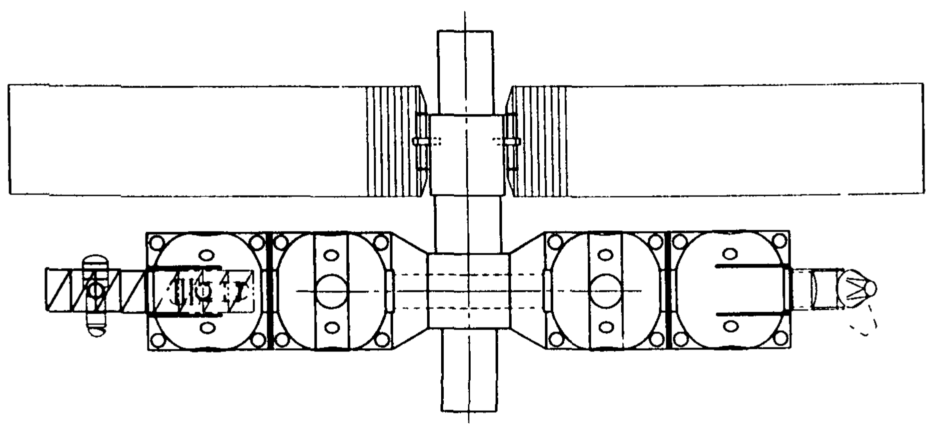
LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

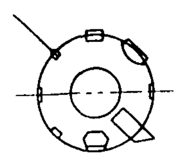
STONEHENGE CONCEPT
VERTICAL OR HORIZONTAL

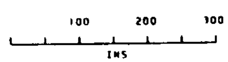
DWN		DATE	
		DWG & MODEL NO 55.14.6	REV
SCALE			SH


CRUCIFORM CONCEPT
55.70
100
200
300
INS





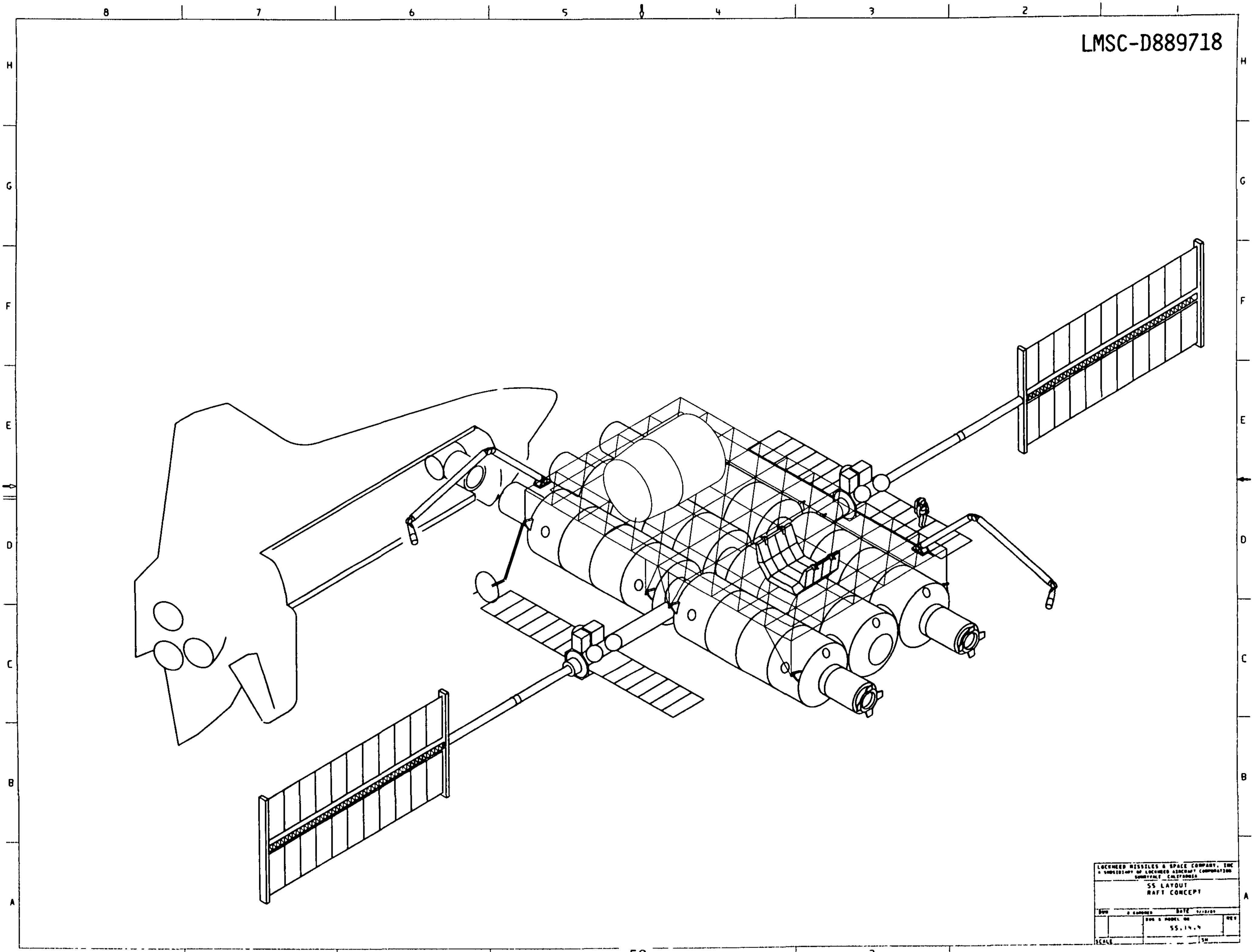




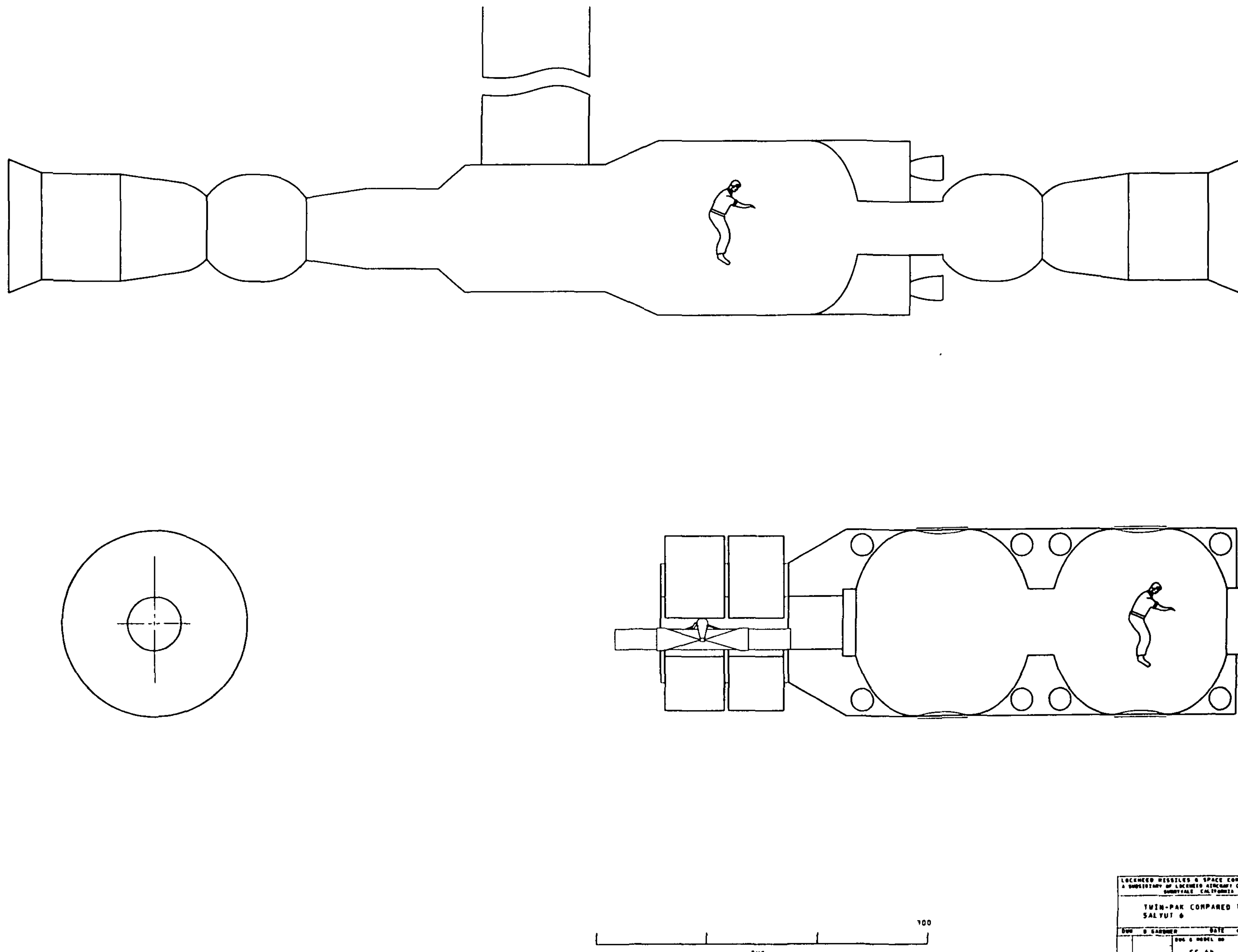
LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

TYP DEVEL/MAINT
HORIZONTAL CONCEPT

DWN | DATE
DWG & MODEL NO | REV
55.72
SCALE | SH


LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA
SS LAYOUT
RAFT CONCEPT
DWN
DATE
DWG & MODEL NO
SS.14.4
REV
SCALE
SH

LMSC-D889718



LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

TWIN-PAK COMPARED TO
SALYUT 6

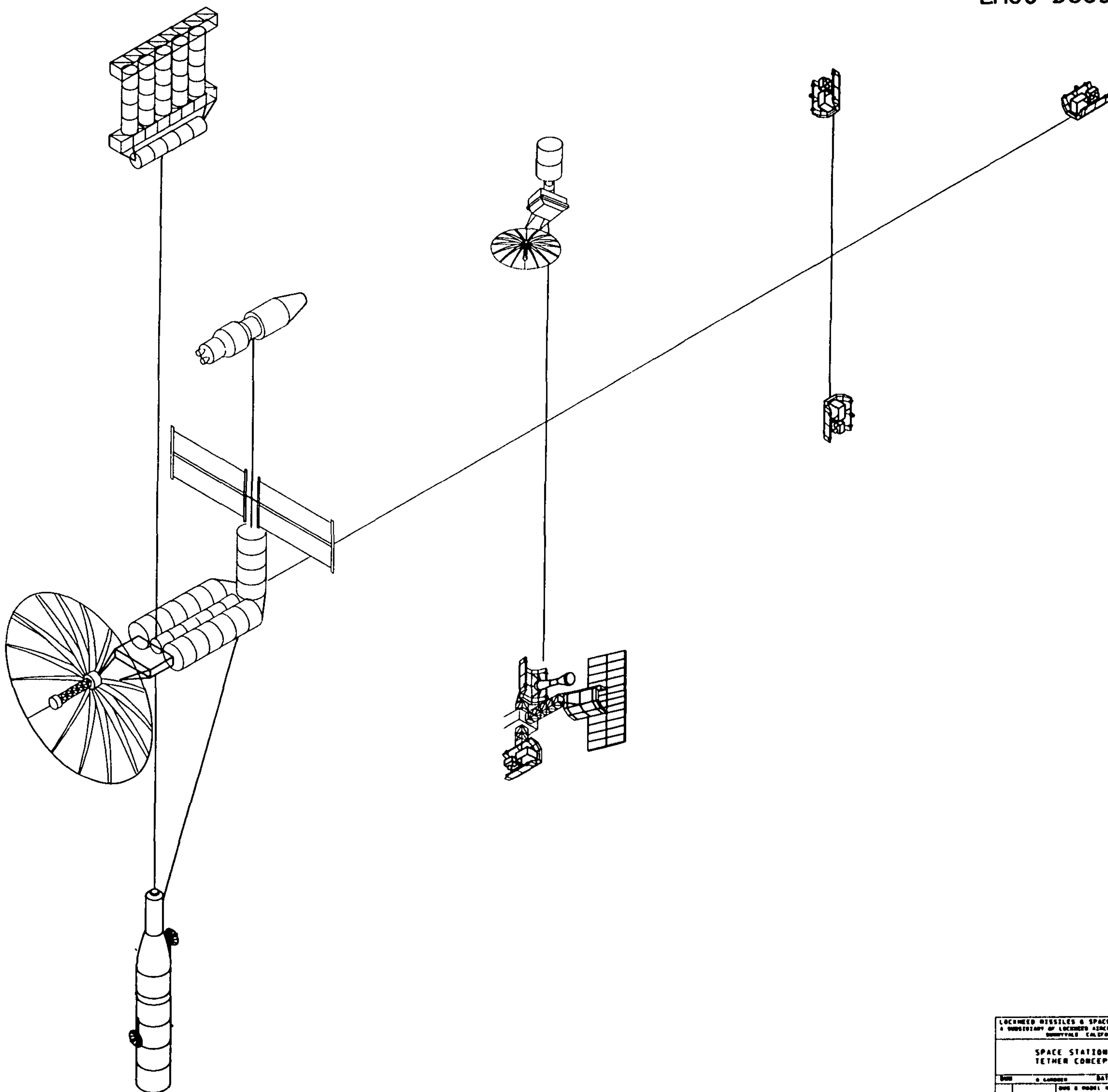
DWN D GARDNER DATE 4/15/82

DWG & MODEL NO 55.64

REV

SCALE

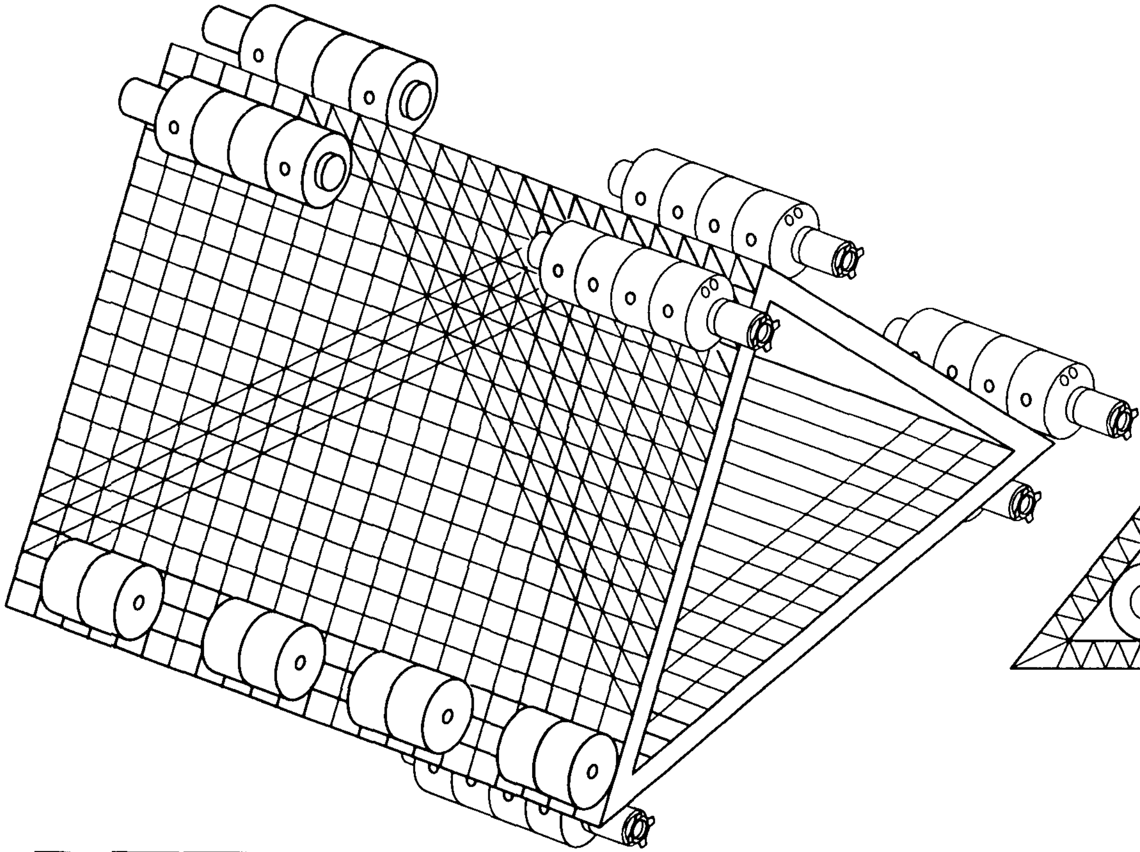
SH

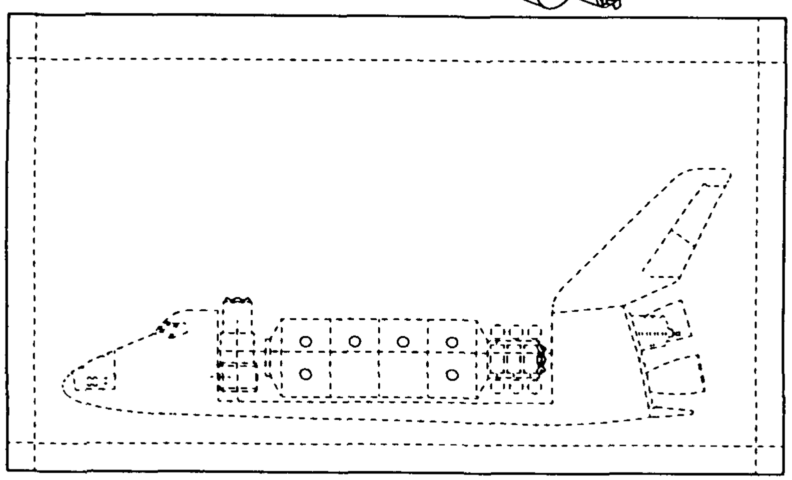


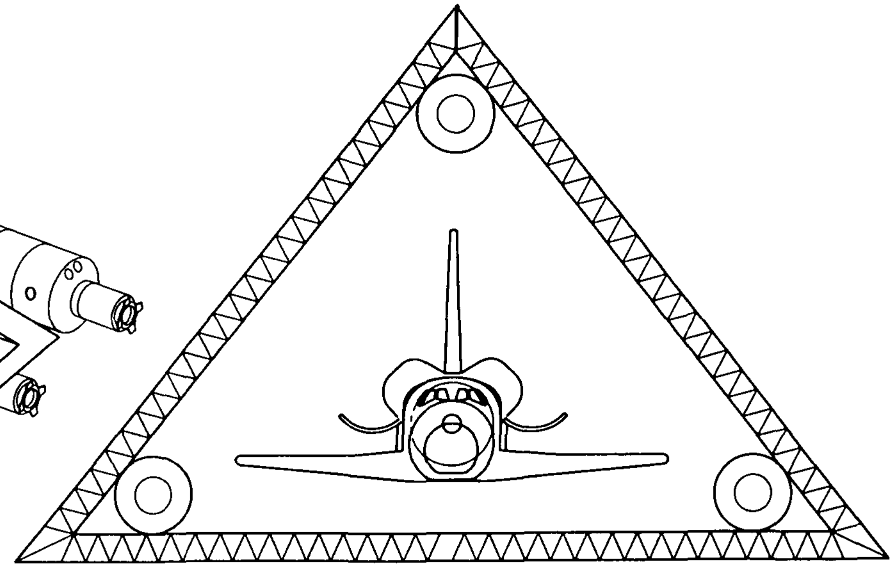
LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

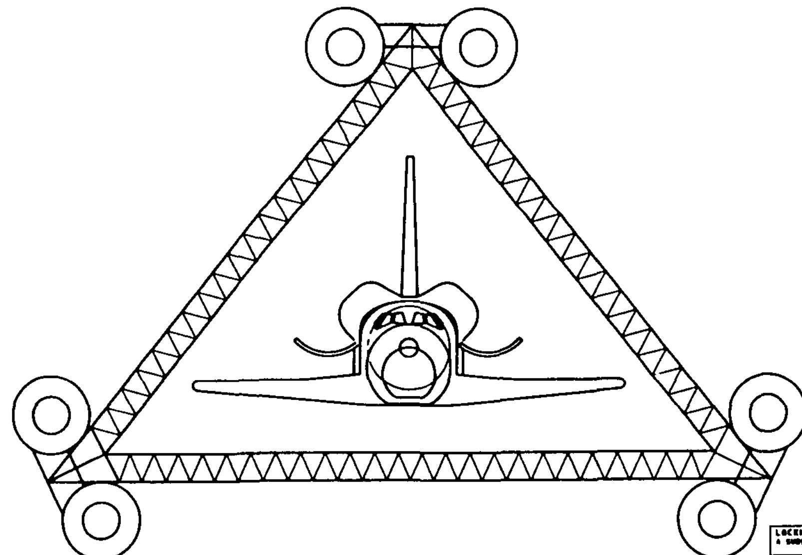
SPACE STATION
TETHER CONCEPT

DWG & MODEL NO 55.17.1









LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

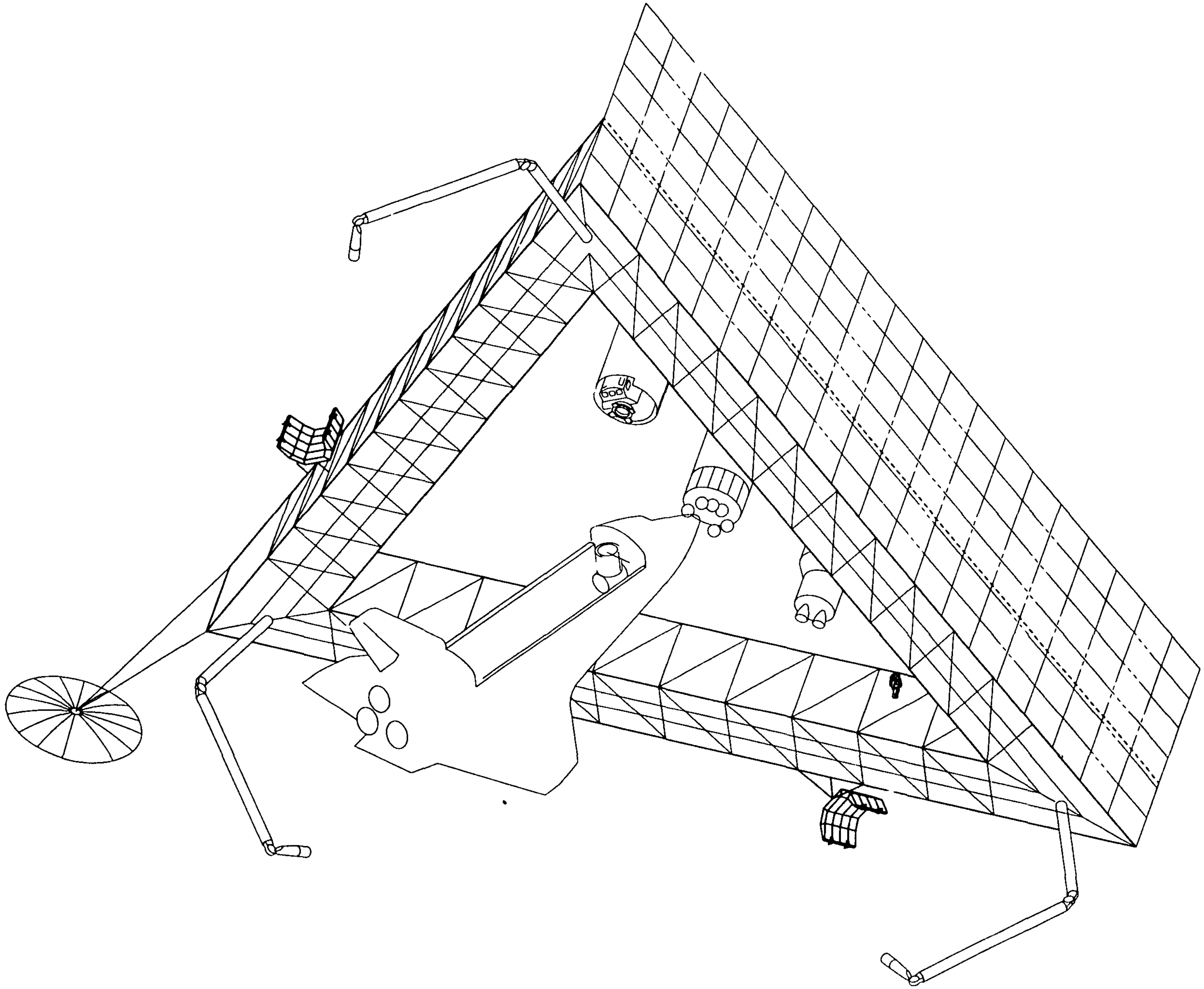
TENT CONCEPT FIXED

DWN | DATE

DWG & MODEL NO
SS.14.0

REV

SCALE | SH



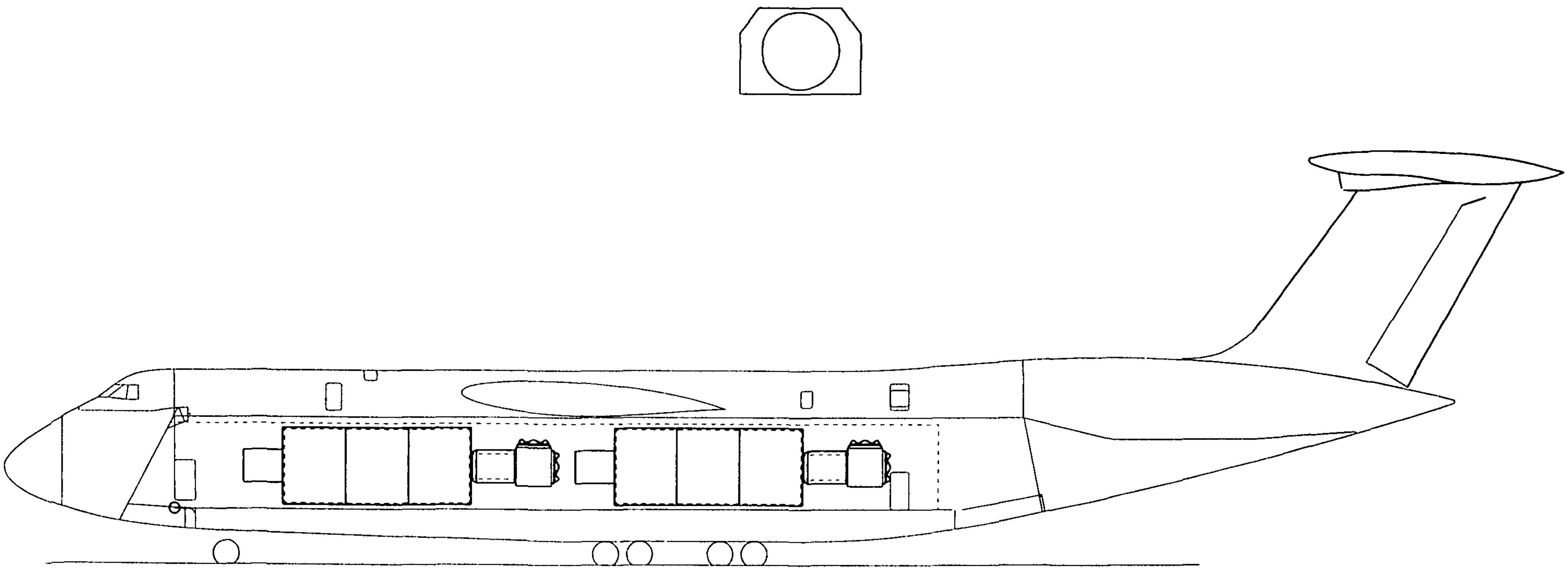
LOCKHEED MISSILES & SPACE COMPANY INC.
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

FIXED TRIANGLE

DWG & MODEL NO 55.14.7

SCALE

LMSC-D889718

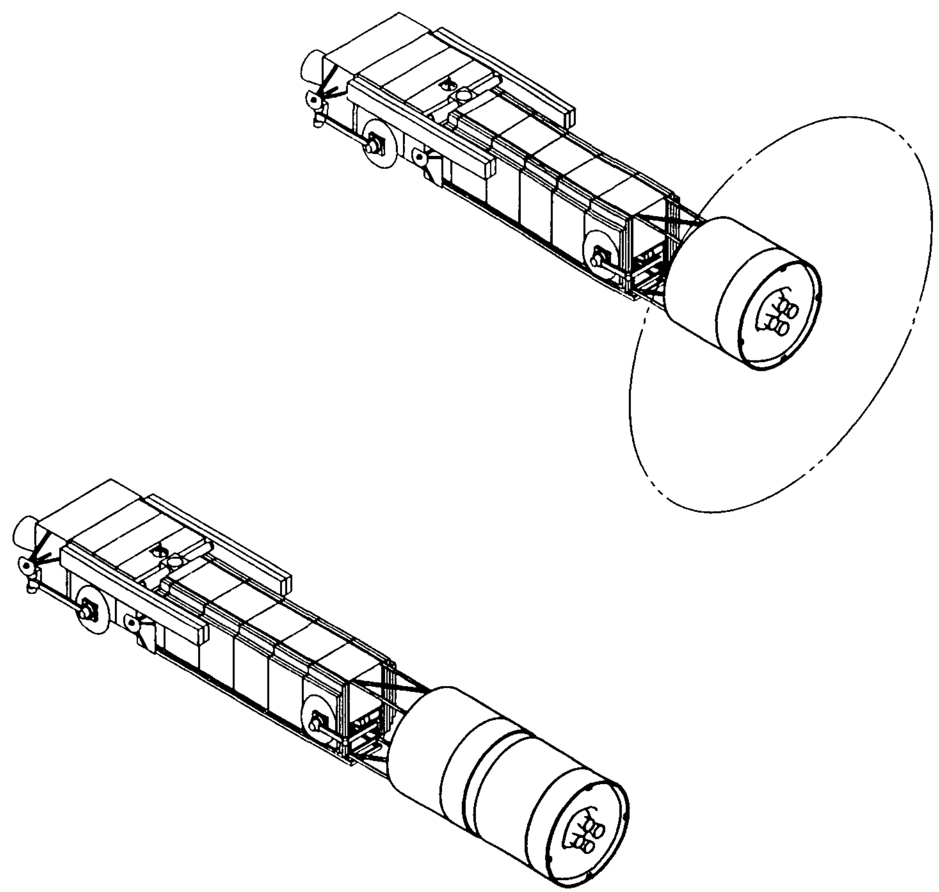


LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

2-12FT SS MODULES IN C5A

DWG & MODEL NO
SS 09

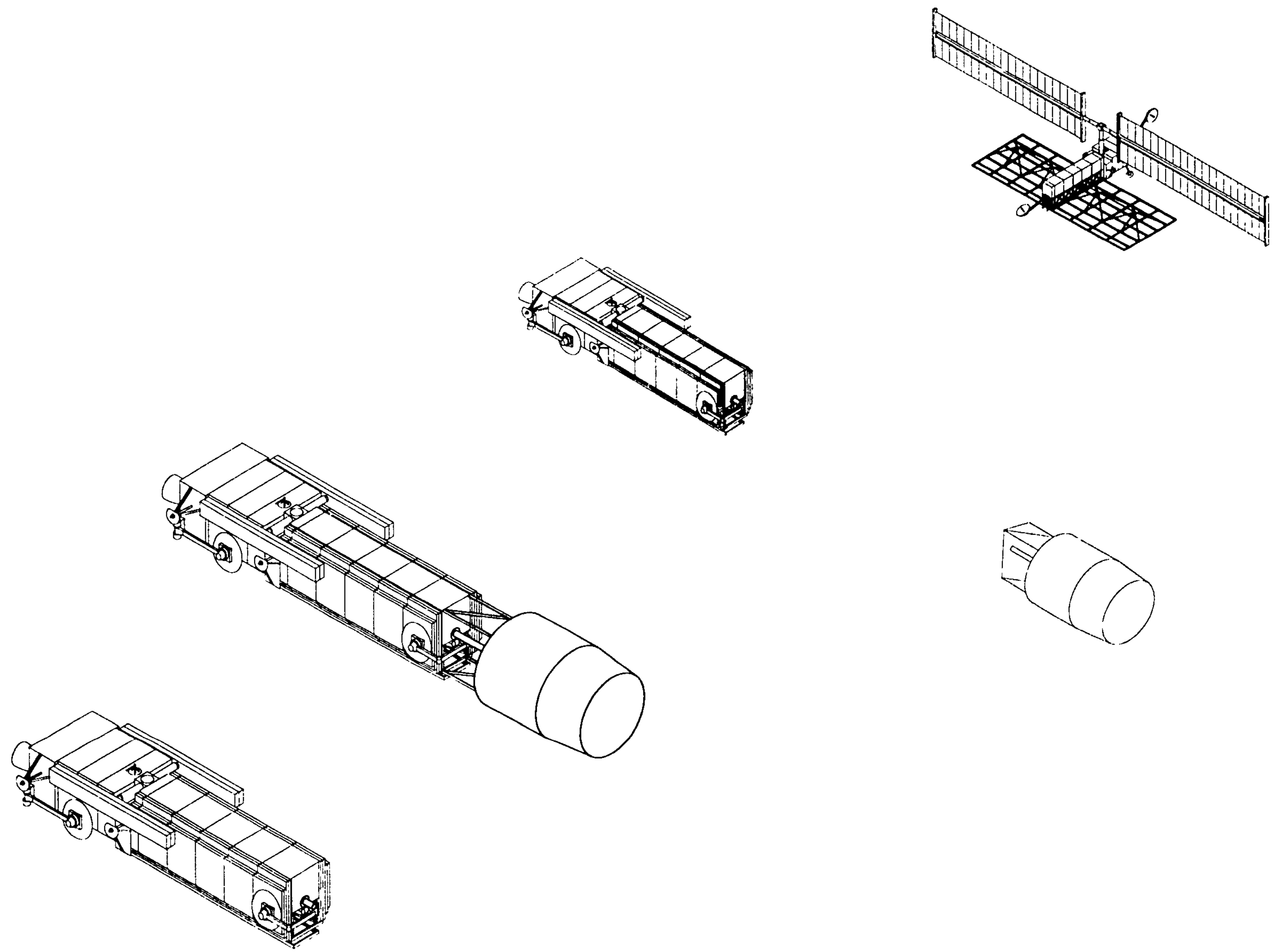
SCALE | SH



LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

SBR/HEUS-OTV
ISO

DWN | DATE
DWG & MODEL NO
SS.15.0
REV
SCALE | SH

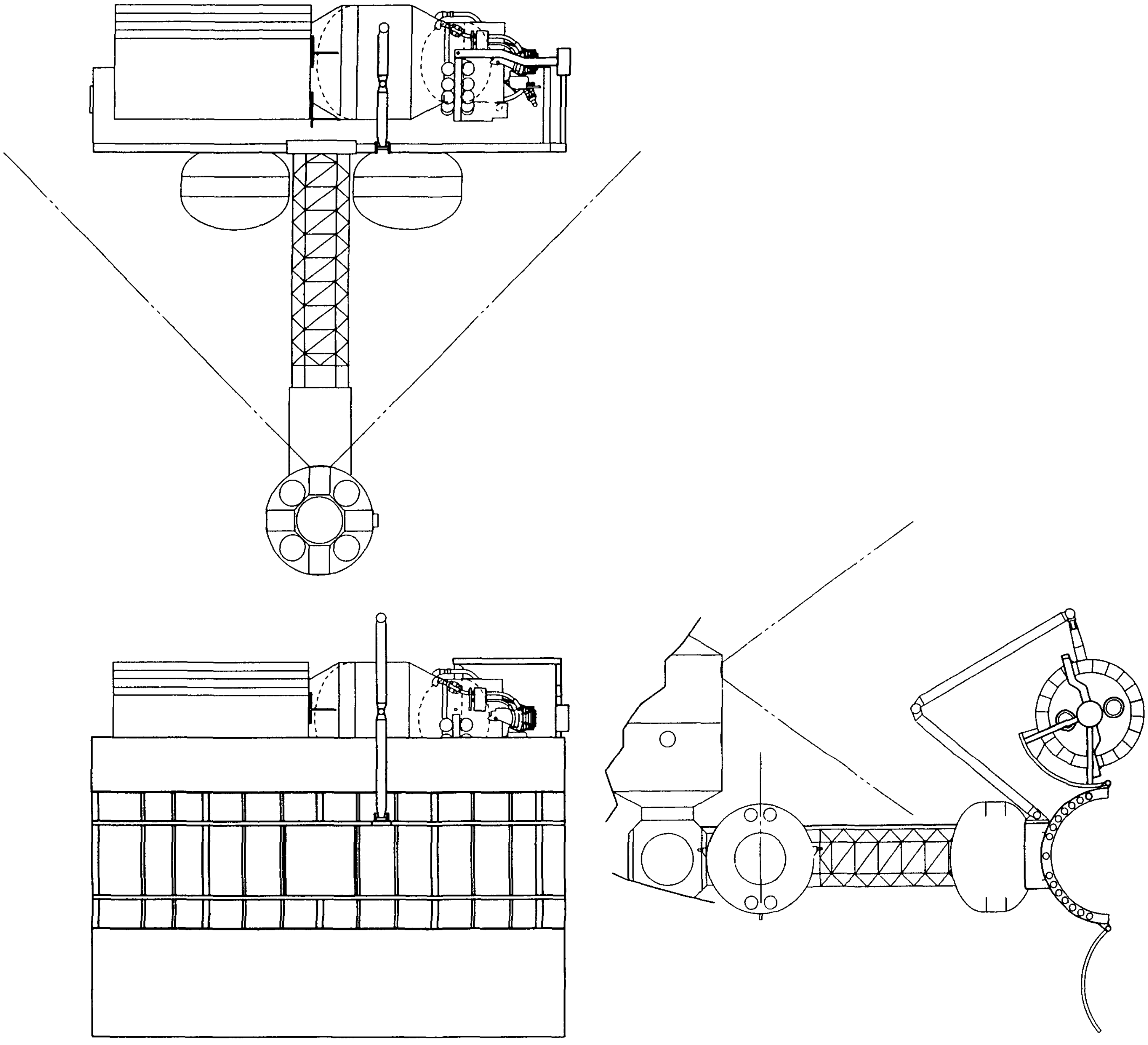


LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

ITSS/OTV CONCEPT

DWN DATE
DWG & MODEL NO REV
SS 12 4
SCALE SH

LOCKHEED MISSILES & SPACE COMPANY,
SHIRTSLEEVE MAN
95TH PERCENTILE
ASTRO.8

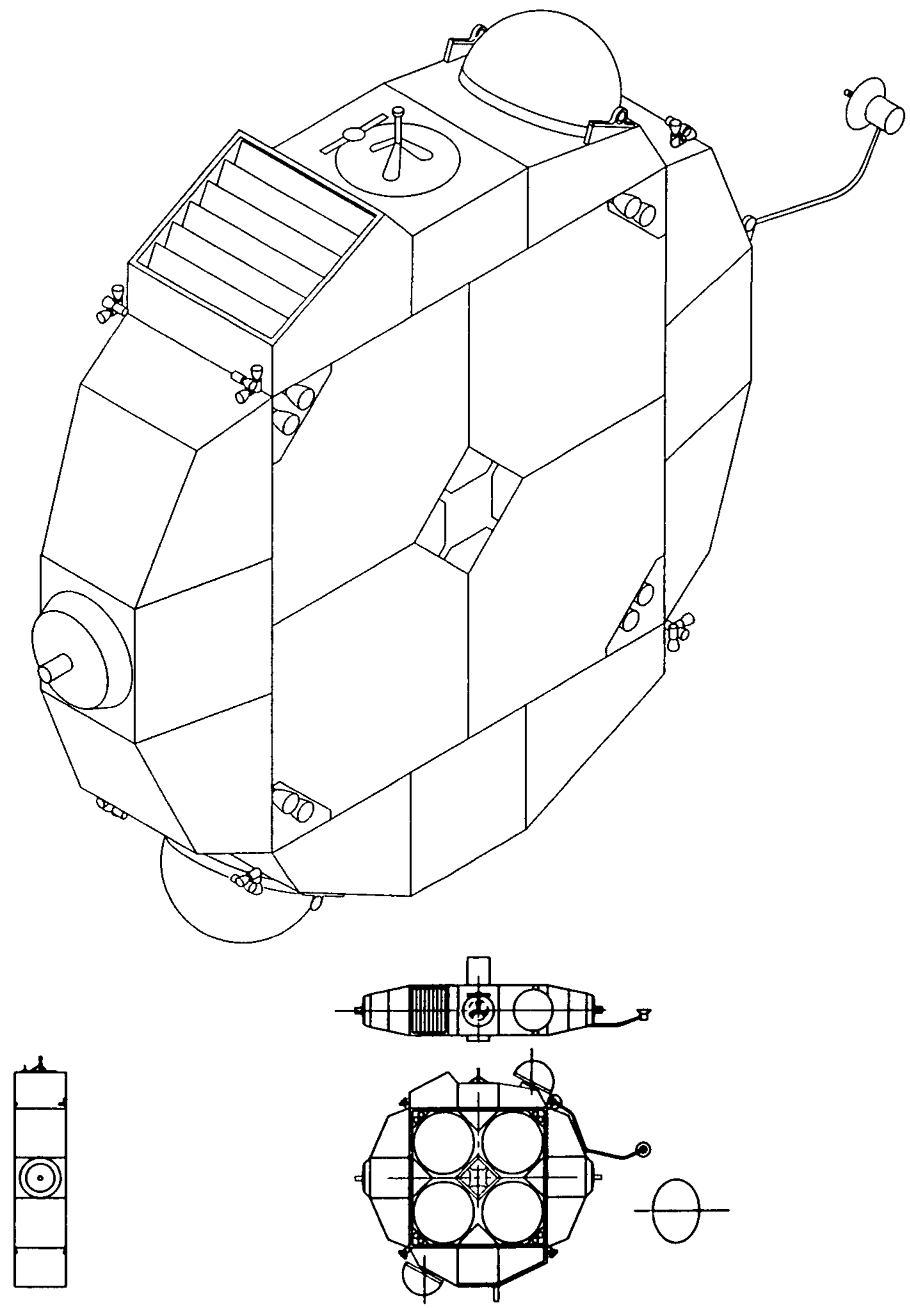


LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

OTV REFUELING STATION

DWG & MODEL NO 55.15.2

LMSC-D889718



LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

TMS ISO

DATE

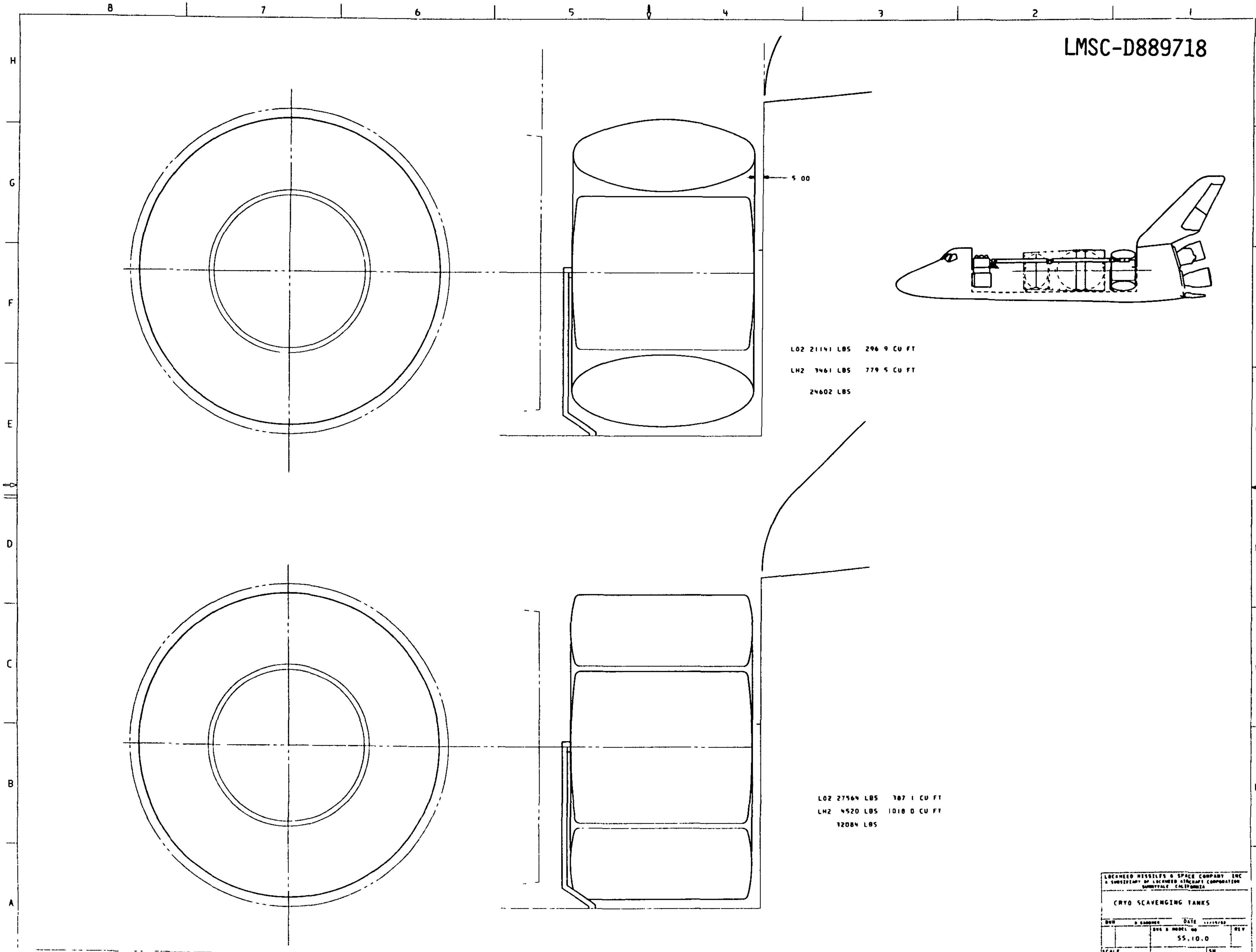
DWG & MODEL NO

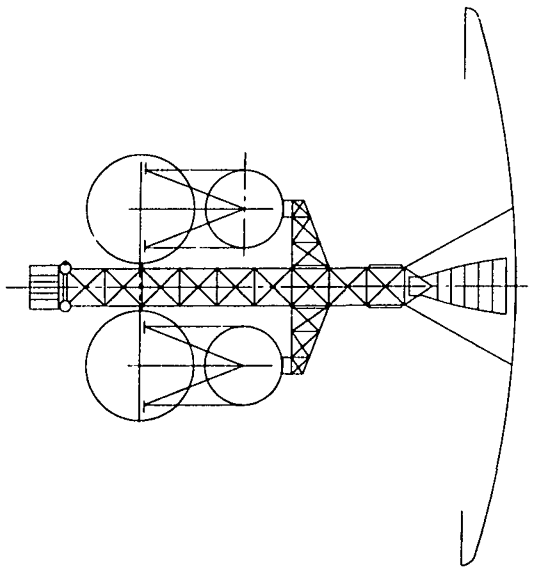
55.96

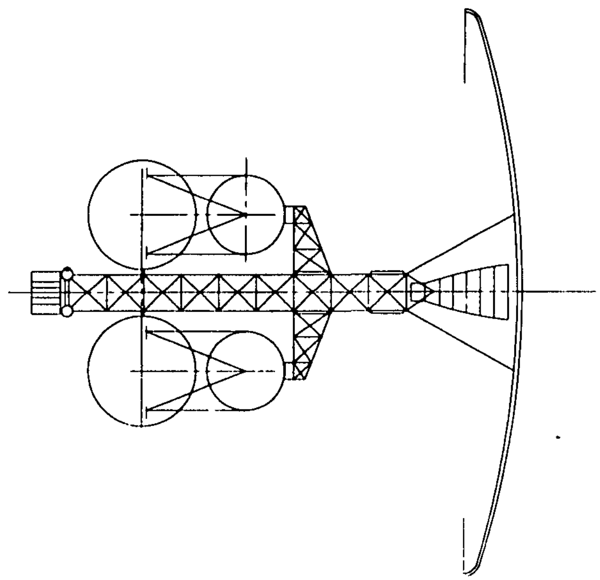
REV

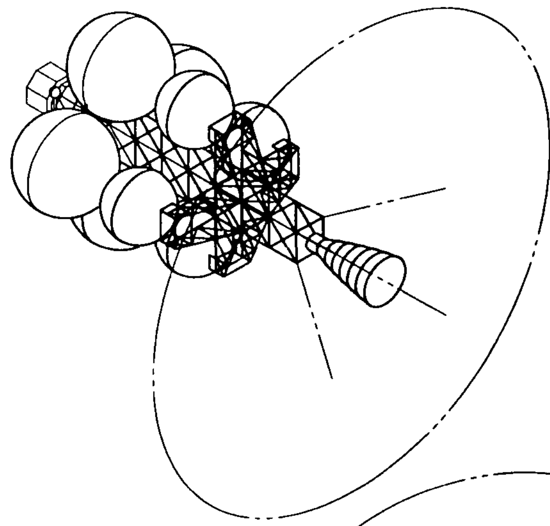
SCALE

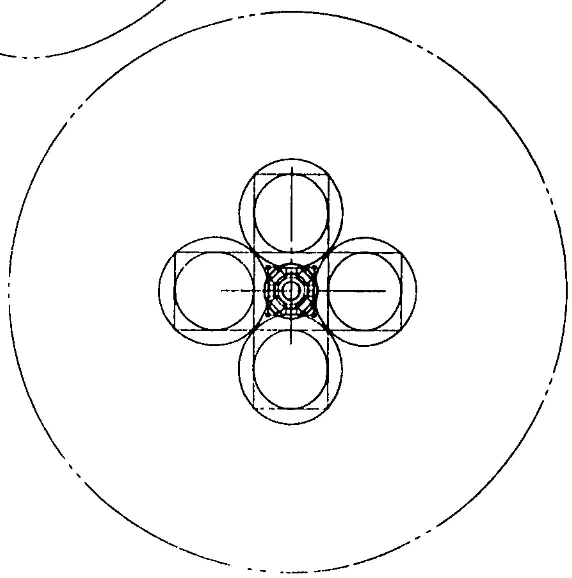
SH

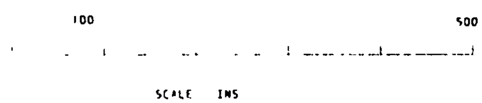

5 00
LO2 21141 LBS 296 9 CU FT
LH2 3461 LBS 779 5 CU FT
24602 LBS
LO2 27564 LBS 387 1 CU FT
LH2 4520 LBS 1010 0 CU FT
32084 LBS
LOCKHEED MISSILES & SPACE COMPANY INC
CRYO SCAVENGING TANKS
DWN
DATE
DWG & MODEL NO
SS.10.0
REV
SCALE
SH







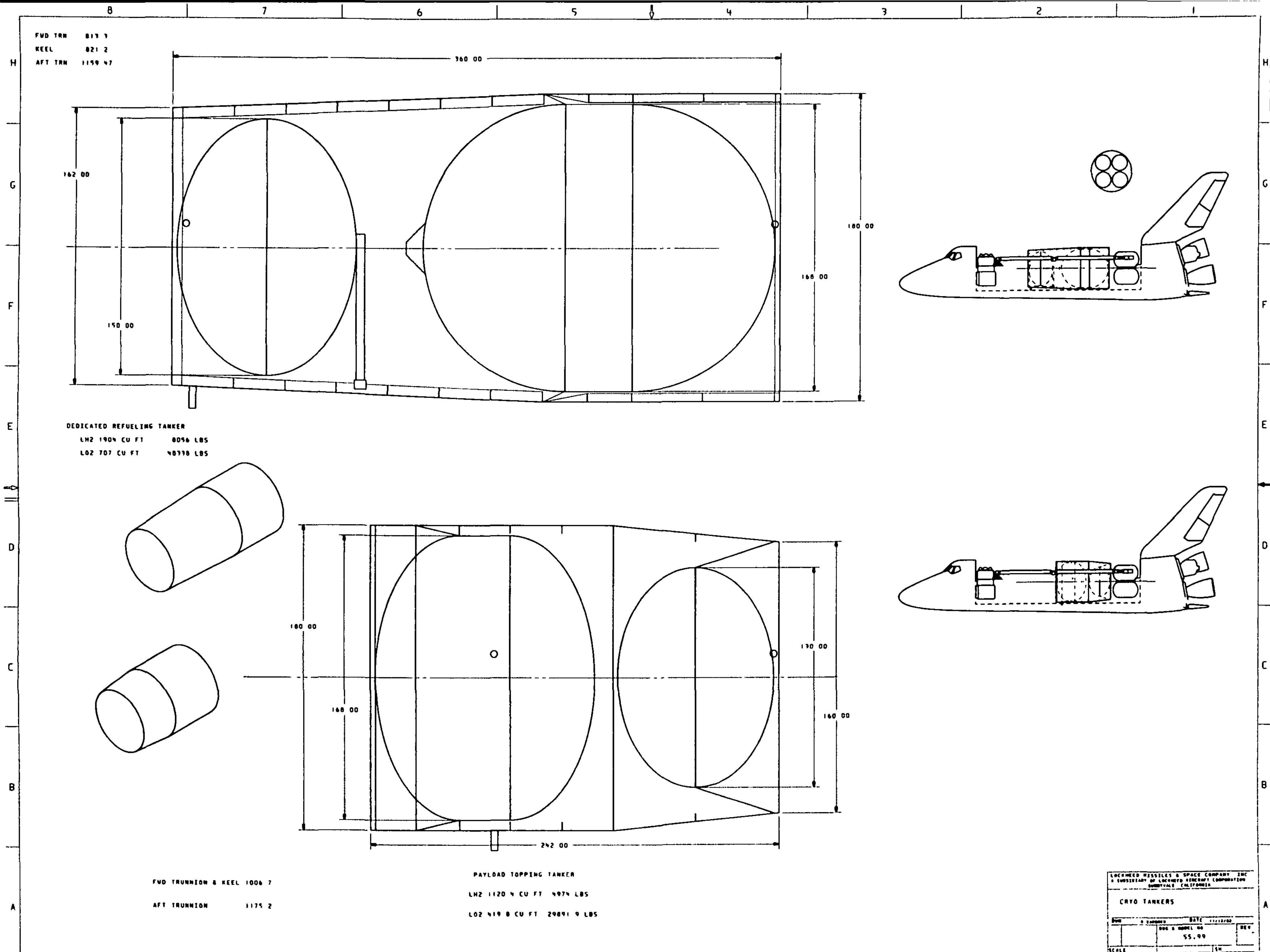




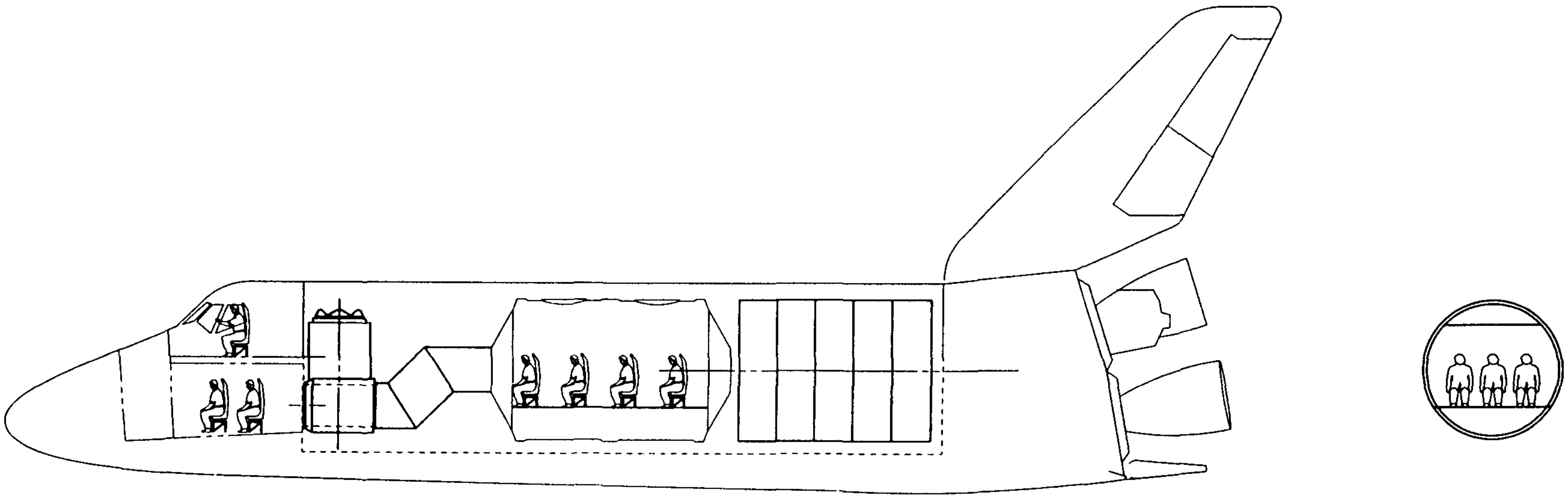
LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

SPACE BASED OTV
GD CONVAIR

DWG NO. 55.11 7


FWD TRN 819 7
KEEL 821 2
AFT TRN 1159 47
360 00
162 00
150 00
180 00
168 00
DEDICATED REFUELING TANKER
LH2 1904 CU FT 8056 LBS
LO2 707 CU FT 48338 LBS
180 00
168 00
130 00
160 00
242 00
FWD TRUNNION & KEEL 1006 7
AFT TRUNNION 1175 2
PAYLOAD TOPPING TANKER
LH2 1120 4 CU FT 4974 LBS
LO2 419 8 CU FT 29891 9 LBS
LOCKHEED MISSILES & SPACE COMPANY INC
CRYO TANKERS
DATE
DWG & MODEL NO
55.99
REV
SCALE
SH

LMSC-D889718

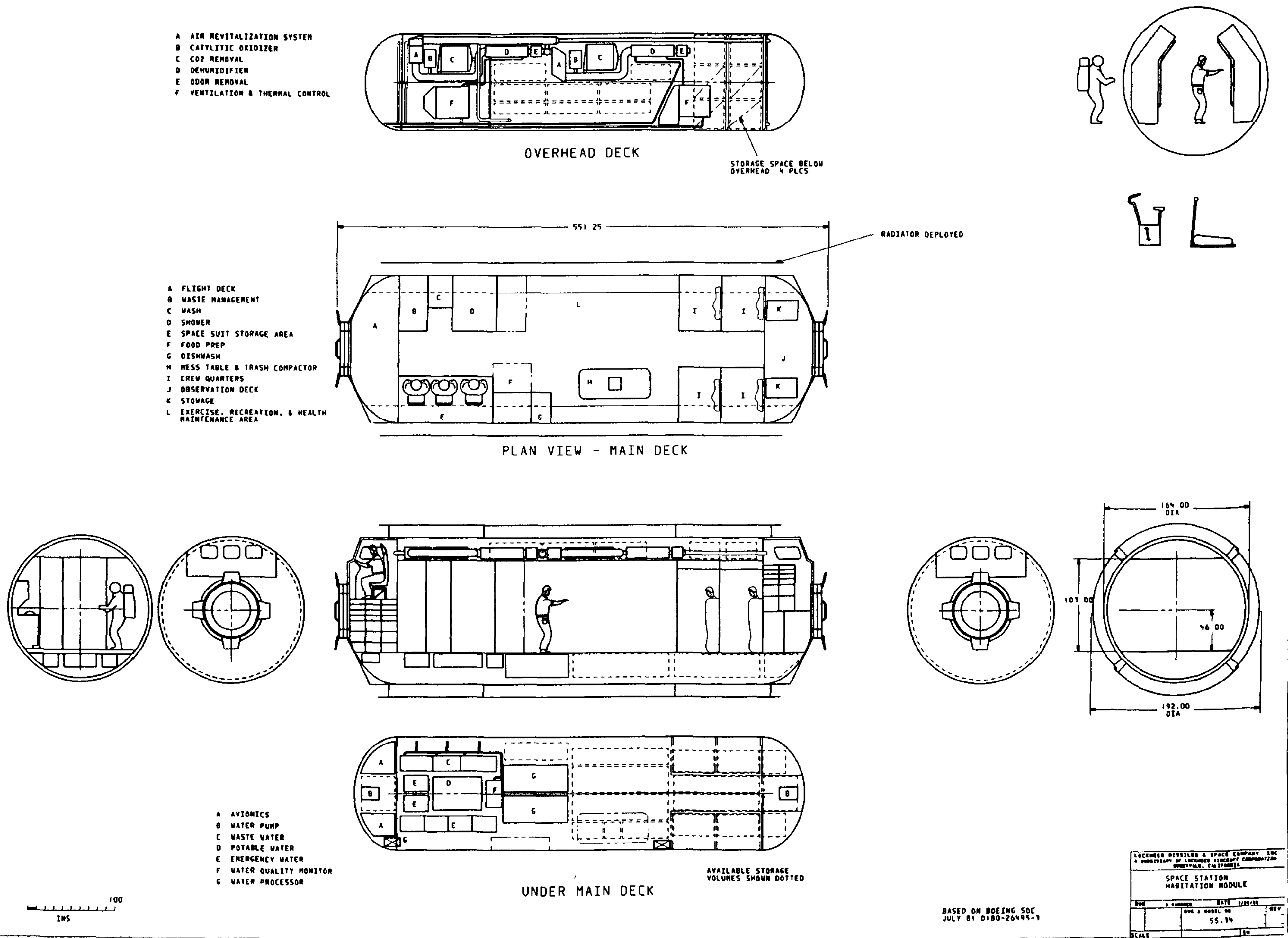


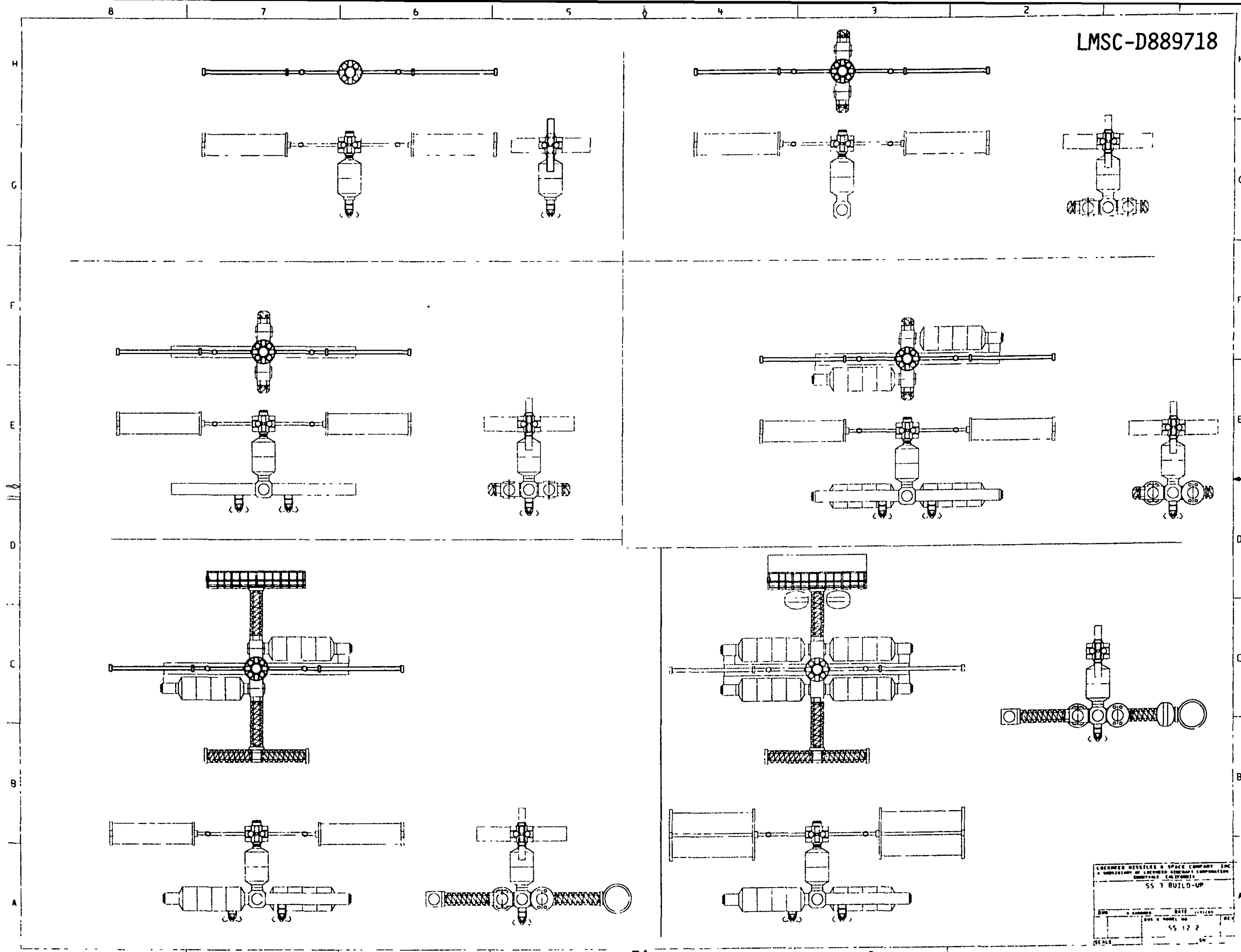
LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

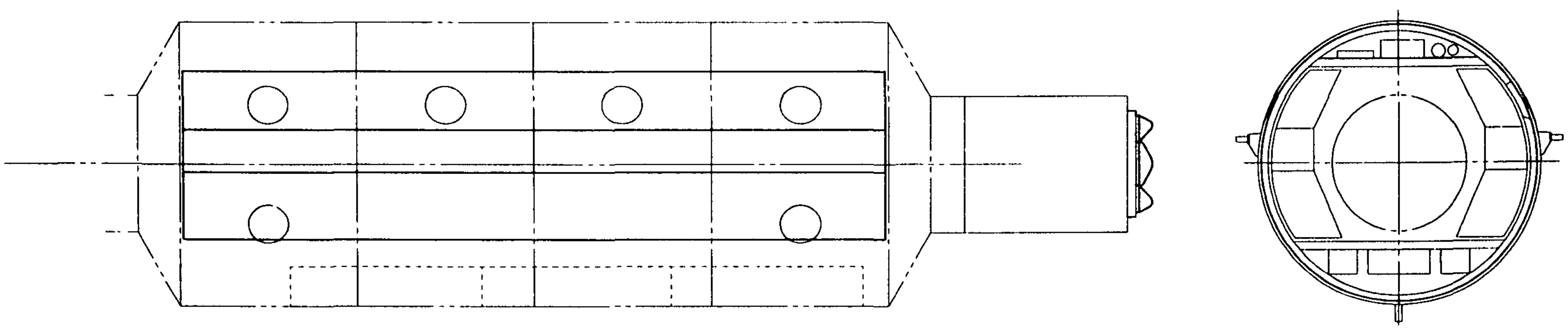
CP LAUNCH CONFIGS
SHT 2

DWG & MODEL NO
SS.15.4

SCALE


A AIR REVITALIZATION SYSTEM
B CATYLITIC OXIDIZER
C CO2 REMOVAL
D DEHUMIDIFIER
E ODOR REMOVAL
F VENTILATION & THERMAL CONTROL
OVERHEAD DECK
STORAGE SPACE BELOW OVERHEAD 4 PLCS
551 25
RADIATOR DEPLOYED
A FLIGHT DECK
B WASTE MANAGEMENT
C WASH
D SHOWER
E SPACE SUIT STORAGE AREA
F FOOD PREP
G DISHWASH
H MESS TABLE & TRASH COMPACTOR
I CREW QUARTERS
J OBSERVATION DECK
K STOWAGE
L EXERCISE, RECREATION, & HEALTH MAINTENANCE AREA
PLAN VIEW - MAIN DECK
164 00 DIA
103 00
46 00
192.00 DIA
A AVIONICS
B WATER PUMP
C WASTE WATER
D POTABLE WATER
E EMERGENCY WATER
F WATER QUALITY MONITOR
G WATER PROCESSOR
UNDER MAIN DECK
AVAILABLE STORAGE VOLUMES SHOWN DOTTED
100
INS
BASED ON BOEING SOC
JULY 81 D180-26495-3
LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA
SPACE STATION
HABITATION MODULE
DWN
DATE
DWG & MODEL NO
55.34
REV
SCALE

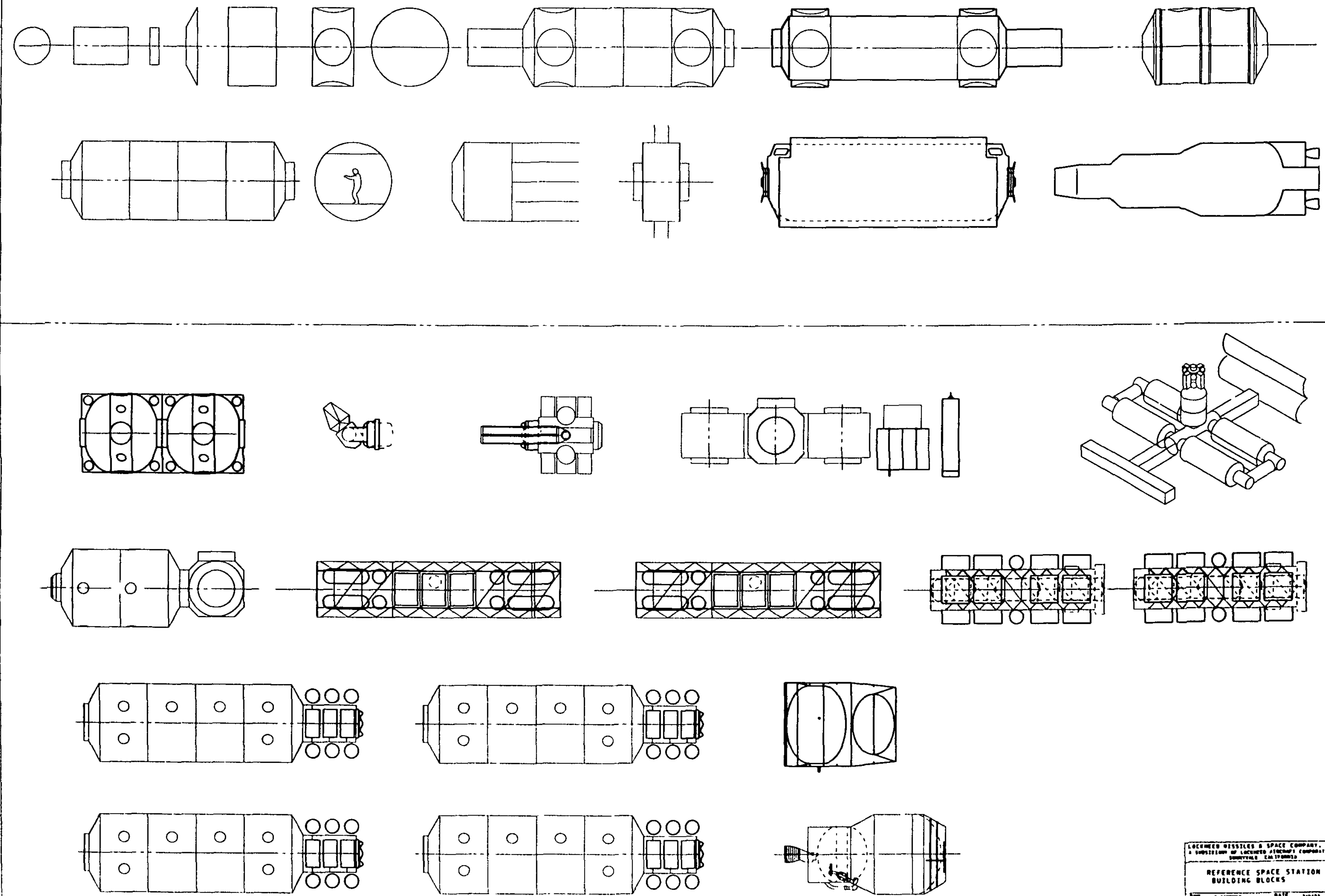

LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA
SS 3 BUILD-UP
DWG
DATE
DWG & MODEL NO
SS 12 2
SCALE



LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

SPACE STATION
EQUIPMENT MODULES

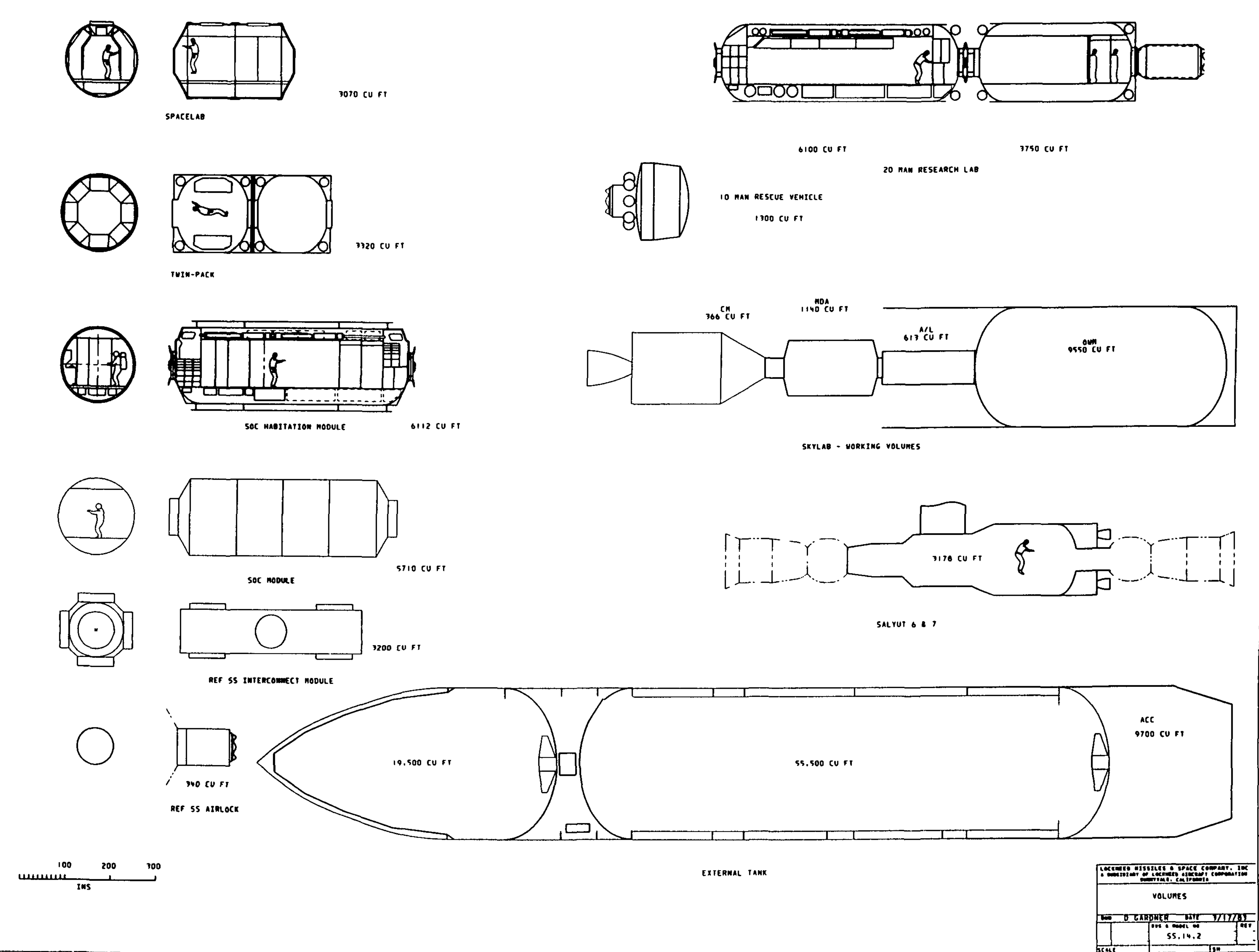
DWN	DATE
DWG & MODEL NO 55.17 D	REV
SCALE	SH

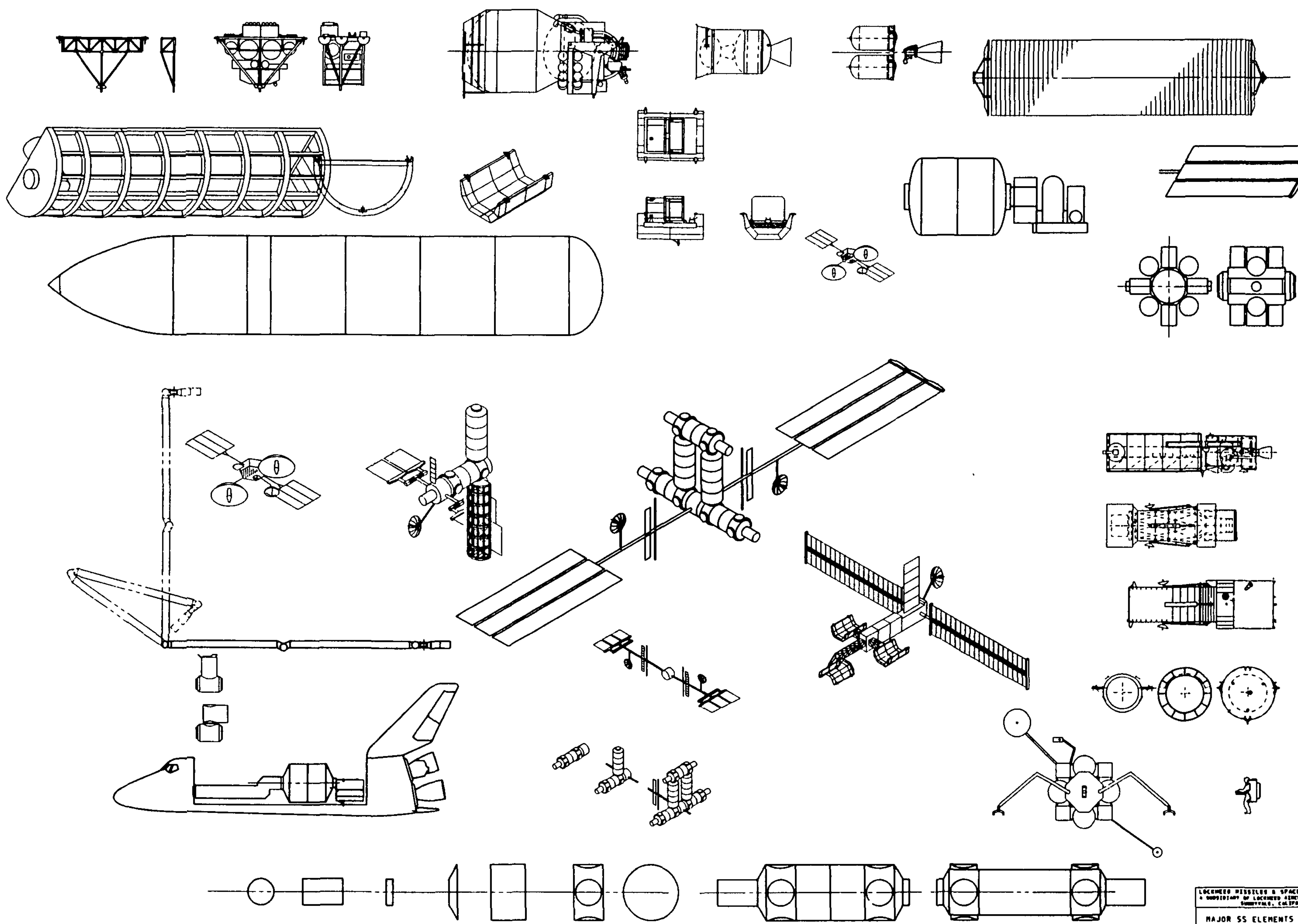


LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

REFERENCE SPACE STATION
BUILDING BLOCKS

55.13.5

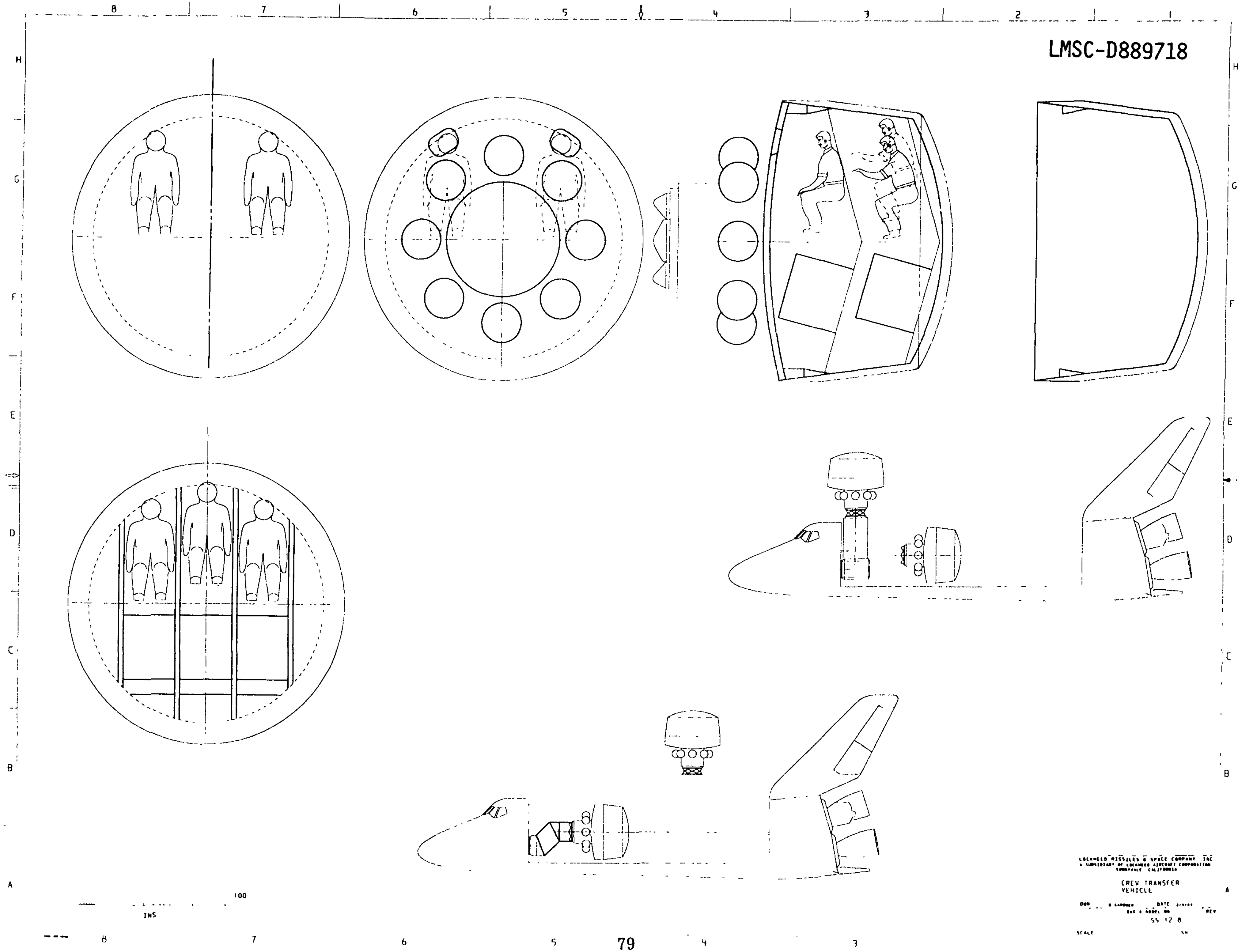

3070 CU FT
SPACELAB
6100 CU FT
3750 CU FT
20 MAN RESEARCH LAB
10 MAN RESCUE VEHICLE
1300 CU FT
3320 CU FT
TWIN-PACK
CM
366 CU FT
MDA
1140 CU FT
A/L
613 CU FT
OWS
9550 CU FT
SOC HABITATION MODULE
6112 CU FT
SKYLAB - WORKING VOLUMES
3178 CU FT
SALYUT 6 & 7
5710 CU FT
SOC MODULE
3200 CU FT
REF SS INTERCONNECT MODULE
ACC
9700 CU FT
19,500 CU FT
55,500 CU FT
340 CU FT
REF SS AIRLOCK
100 200 300
INS
EXTERNAL TANK
VOLUMES
D GARDNER
55.14.2

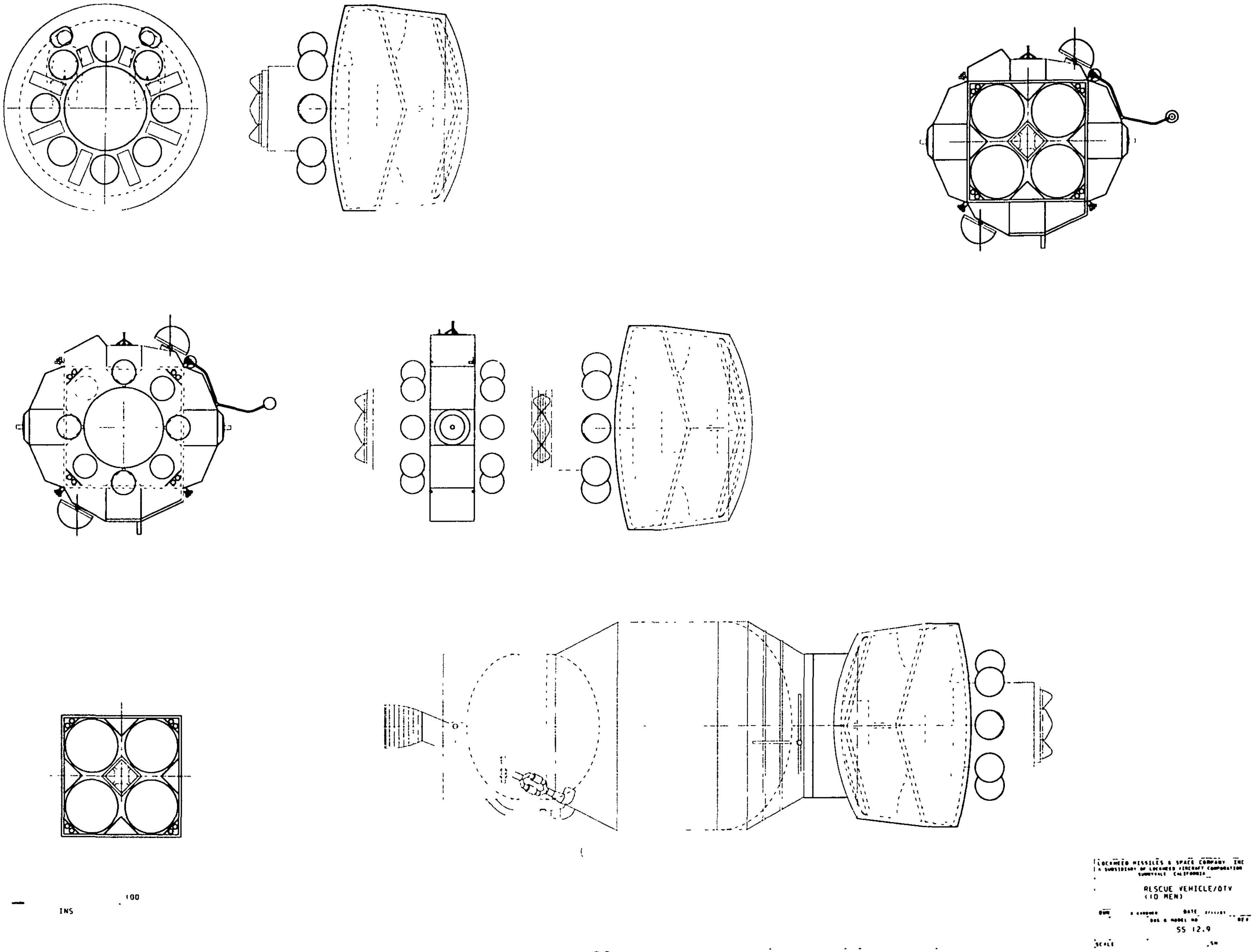


LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

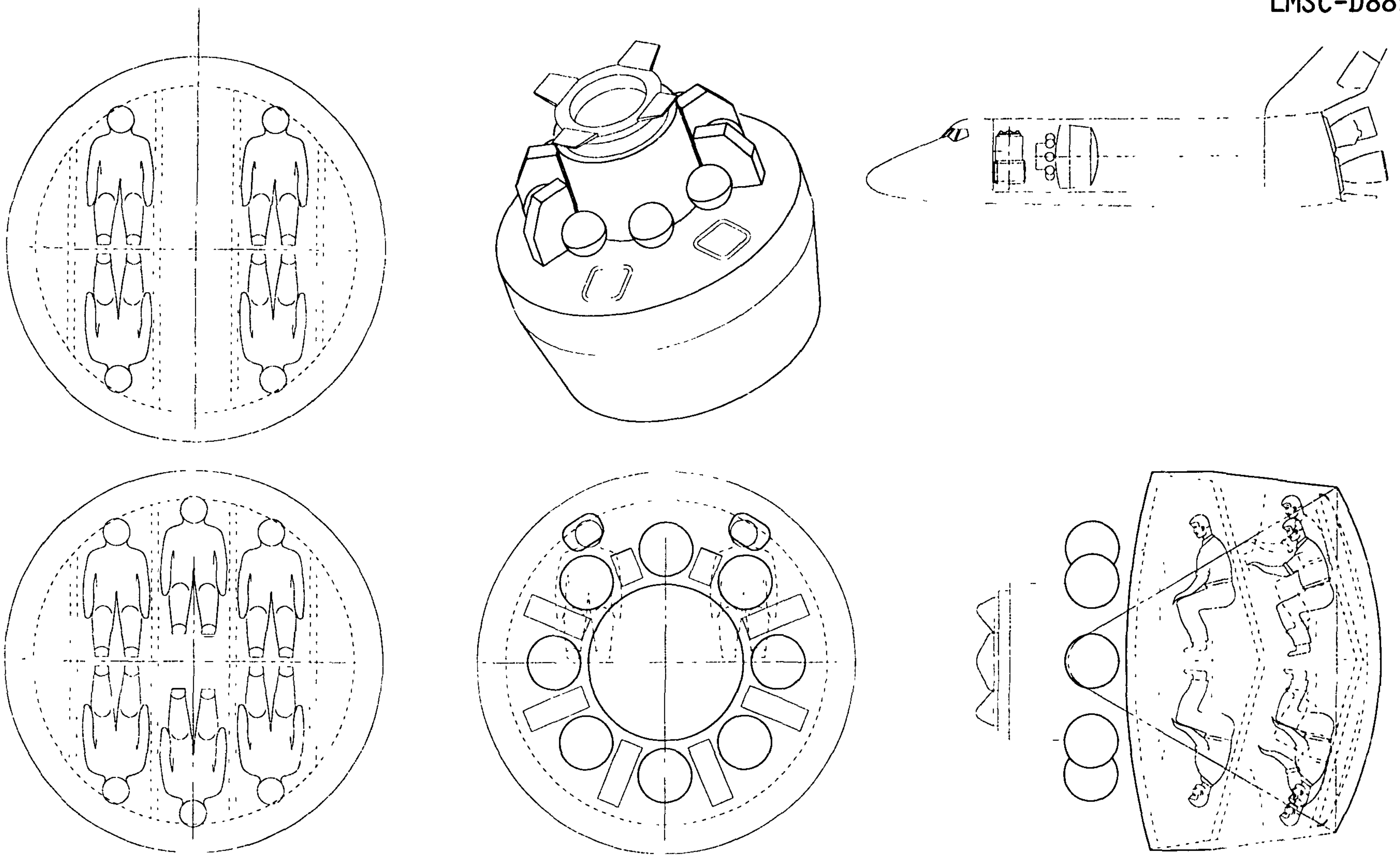
MAJOR SS ELEMENTS

DWN		DATE	
DWG & MODEL NO	55.25	REV	
SCALE		SH	


LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA
CREW TRANSFER
VEHICLE
DWG
DATE
DWG & MODEL NO
REV
SS 12 8
SCALE
SH
100
INS



INS
100
LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA
RESCUE VEHICLE/OTV
(10 MEN)
SS 12.9
SCALE

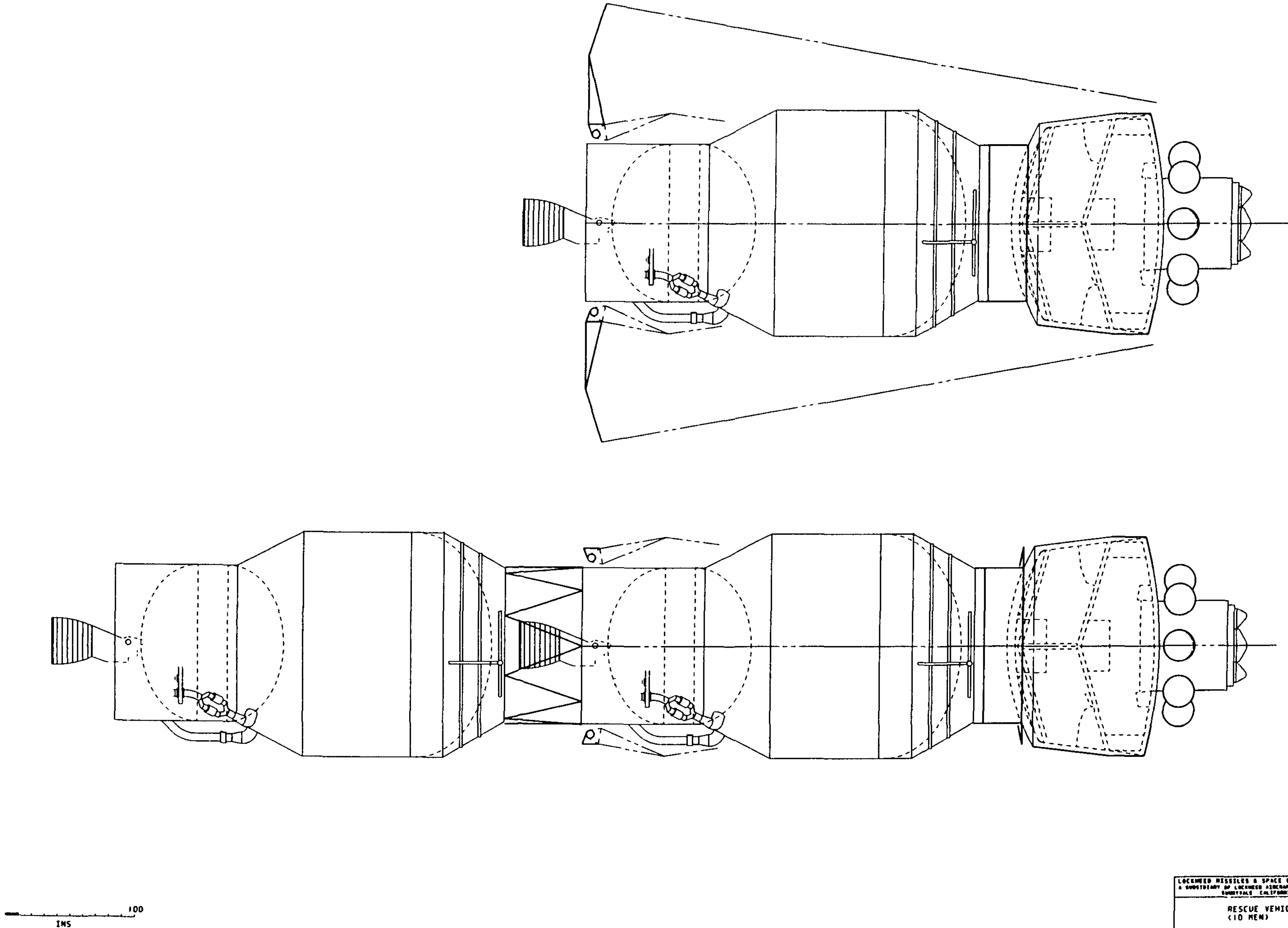


LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

RESCUE VEHICLE
(10 MEN)

DWN DATE
DWG & MODEL NO REV
55.12 7

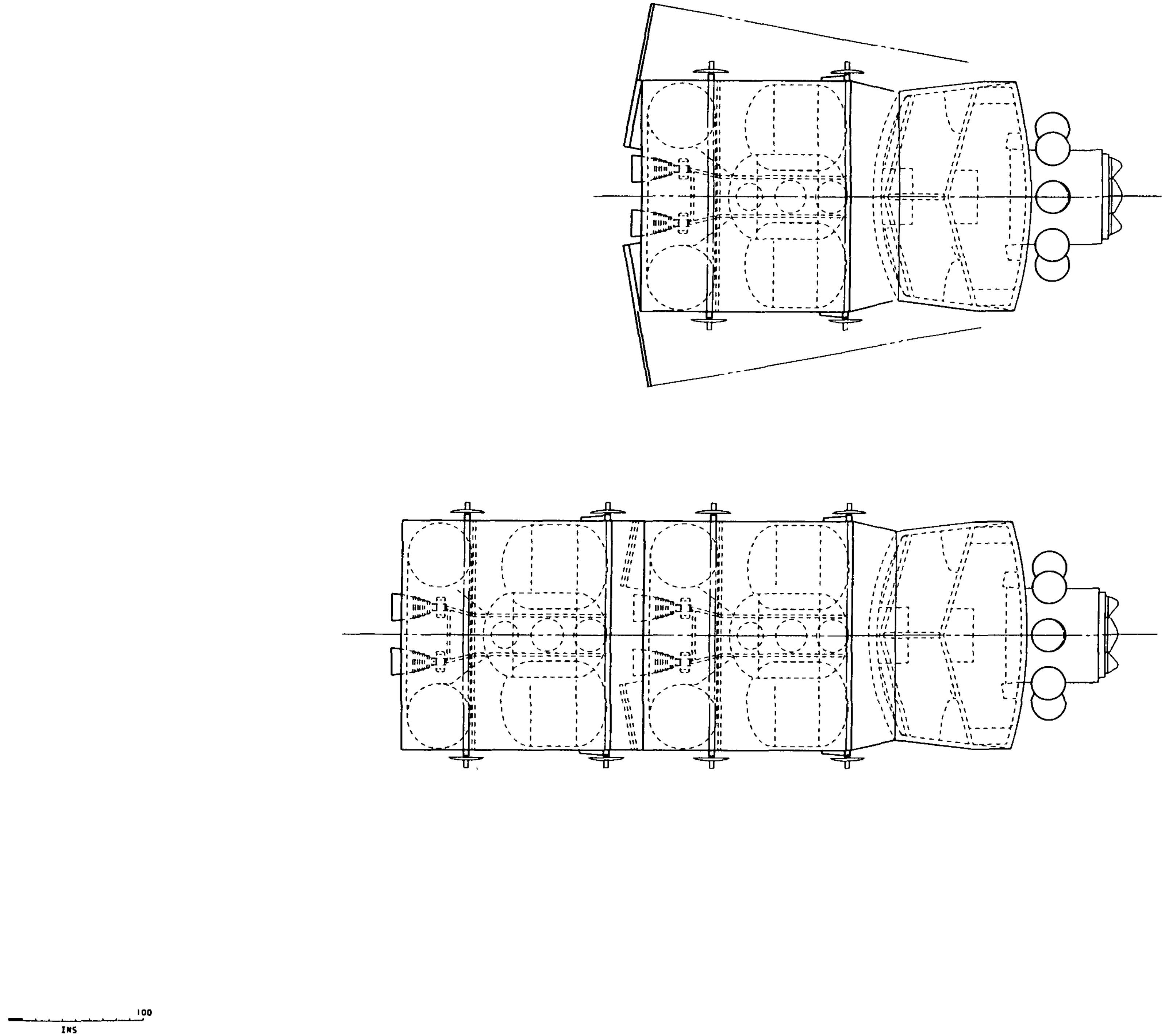
SCALE SH



LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

RESCUE VEHICLE/OTV
(10 MEN)

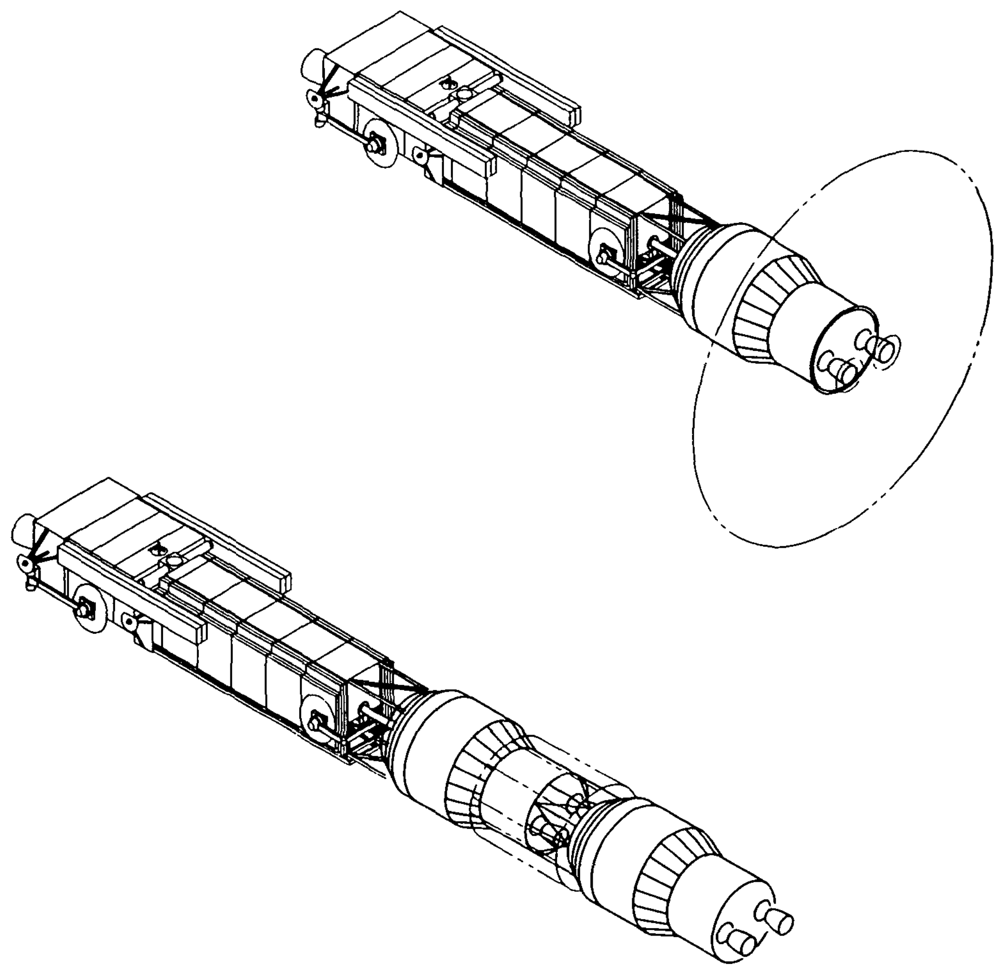
DWN | DATE
DWG & MODEL NO 55.17.6 | REV -
SCALE | SH



LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

RESCUE VEHICLE/MEUS OTV
(10 MEN)

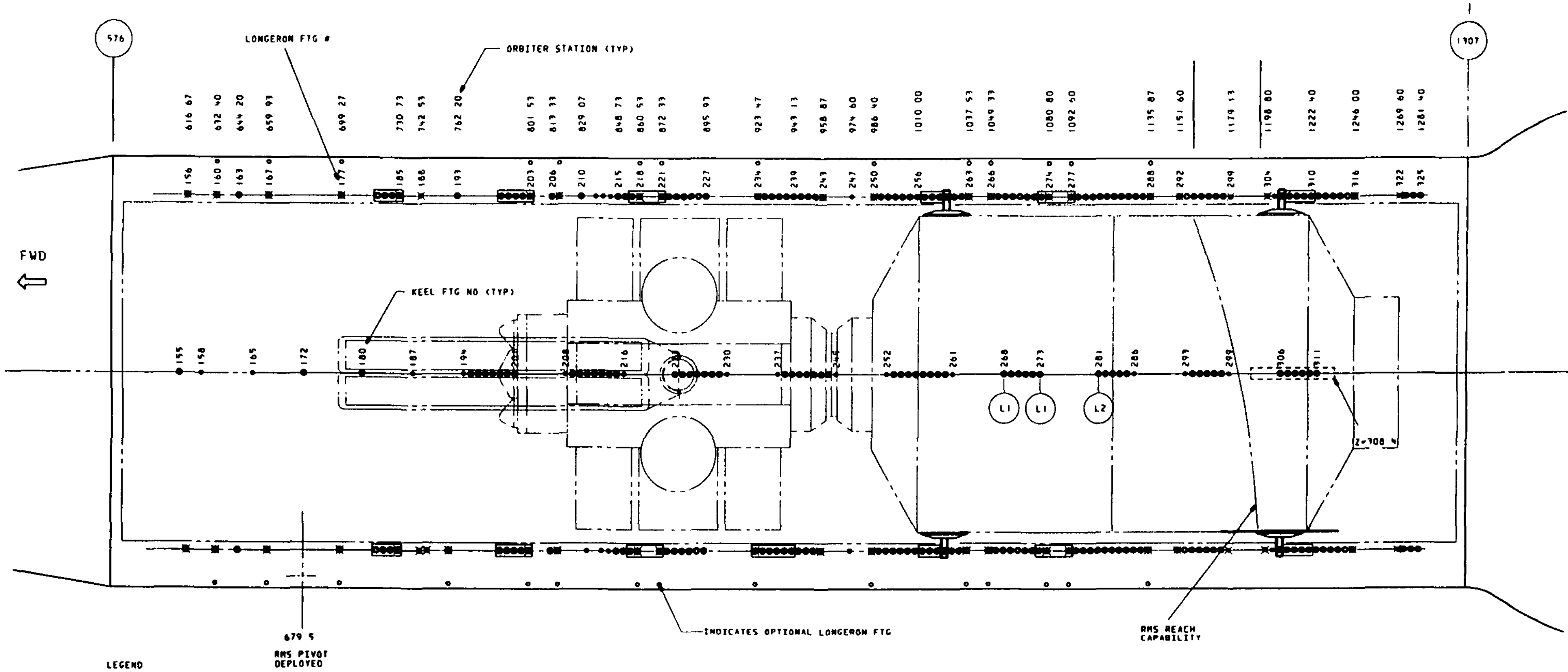
DATE
DWG & MODEL NO
55.17.9
REV
SCALE
SH



LOCKHEED MISSILES & SPACE COMPANY, INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

SBR/OTV

DWG & MODEL NO 55.14.9



LEGEND

- ∘ NON-DEPLOYABLE, FIXED OR SLIDING
- ● DEPLOYABLE, FIXED OR SLIDING
- ✕ NON-DEPLOYABLE, FIXED ONLY
- ■ DEPLOYABLE, FIXED ONLY
- ▭ SMALL RETRIEVAL TRUNNION GUIDE (8 IN) ONLY

ALLOWABLE LIMIT LOAD

+Z - 46 5K (TRUNNION)

-Z - 51 6 " "

+Y - 53 0K (KEEL)

ALLOWABLE LIMIT LOAD

+Z - 126 34K (TRUNNION)

-Y - 120 0K " "

X IS FORE & AFT

Y IS SIDE TO SIDE

Z IS UP & DOWN

NOTES

1. (L1) INDICATES LIMITATIONS TO RETRIEVAL CAPABILITY LONGERON FTG SPACING > OR = 100 IN
2. (L2) INDICATES LIMITATIONS TO RETRIEVAL CAPABILITY LONGERON FTG SPACING > OR = 70 IN
3. ORBITER STATION $= \frac{\text{FTG NO} \times 59}{15} + 3\ 07$

50 100

TAKEN FROM
DWG NO SA05-010.01.01
REV (B)
E F CAVEY 15 JUL 80
66-01

LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

SPACE STATION/ORBITER STRUCTURAL INTERFACES

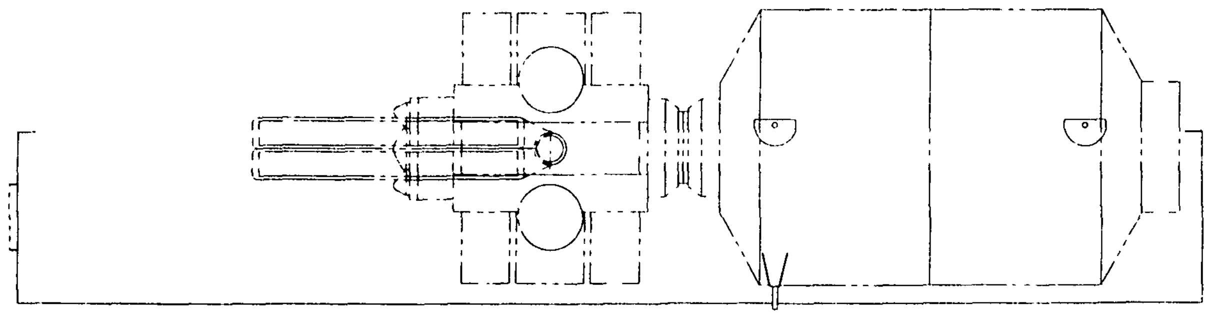
DWN R. GARDNER DATE 1/91/81

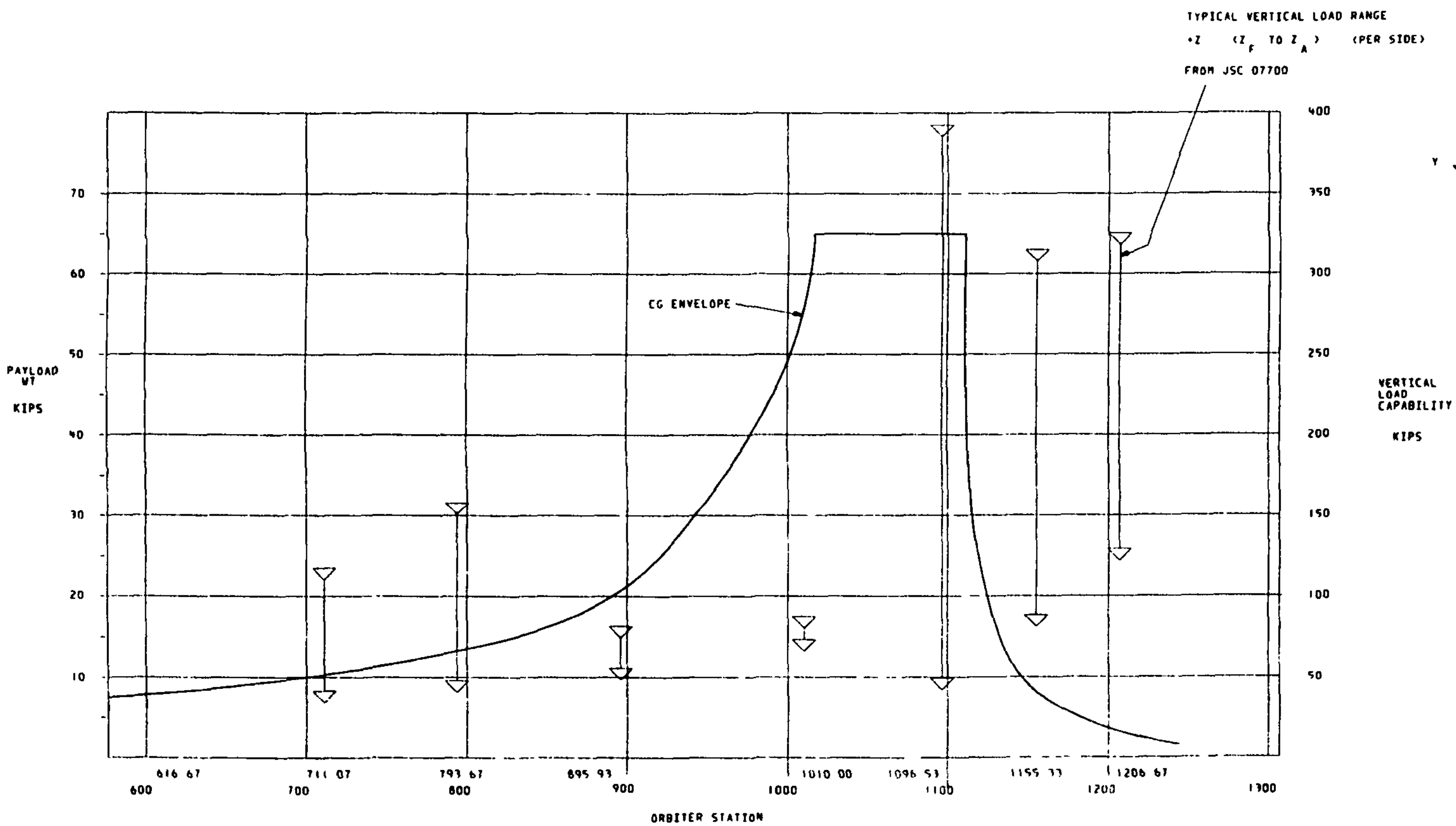
DWG & MODEL NO 55.12 0

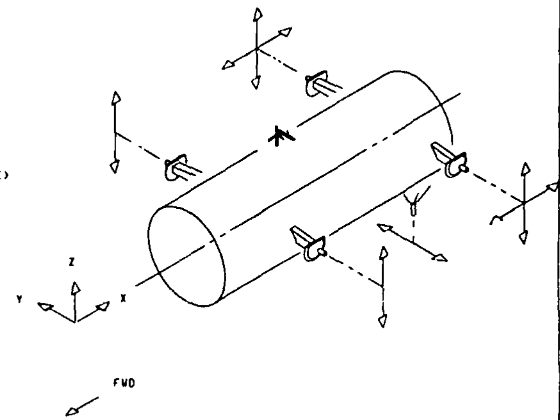
SCALE SH 2 OF 9

(IF ALL X LOAD IS TAKEN BY 2 AFT TRUNNIONS)

???







TYPICAL 5 POINT PAYLOAD RETENTION SYSTEM
INDETERMINATE

NOTE
THIS IS TO PROVIDE QUICK LOOK CAPABILITY FOR INITIAL CONCEPT TYPE WORK ONLY FOR X & Y LOAD CAPABILITY. MODIFIERS, VIBRATION STUFF ETC SEE YOUR FAVORITE LOADS MAN & JSC 07700

LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA

SS BASIC MODULE IN ORBITER C G RESTRAINTS

DWN B. GARDNER DATE 1/31/83

DWG & MODEL NO SS.12.1

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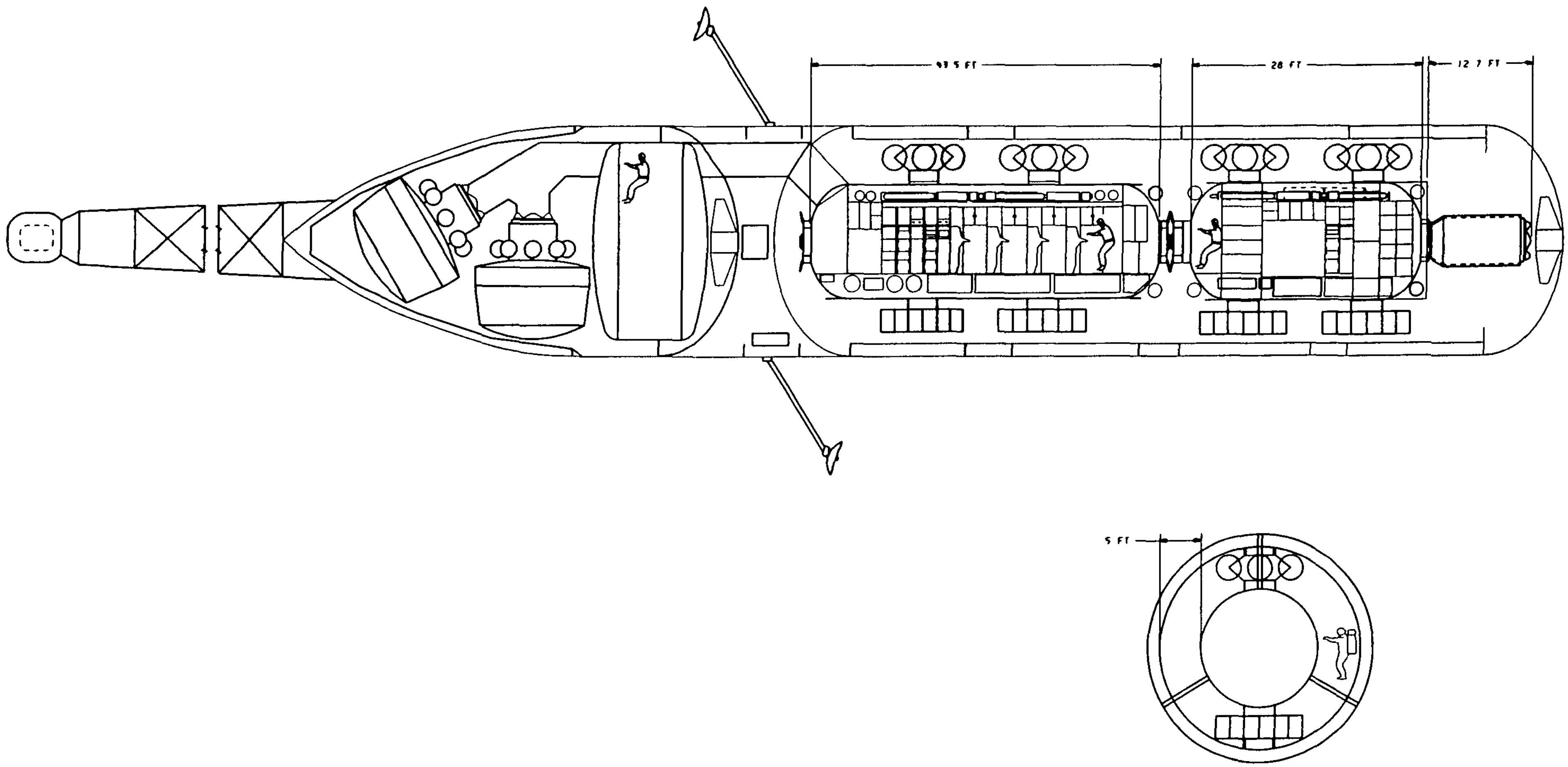

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LOCKHEED MISSILES & SPACE COMPANY, INC

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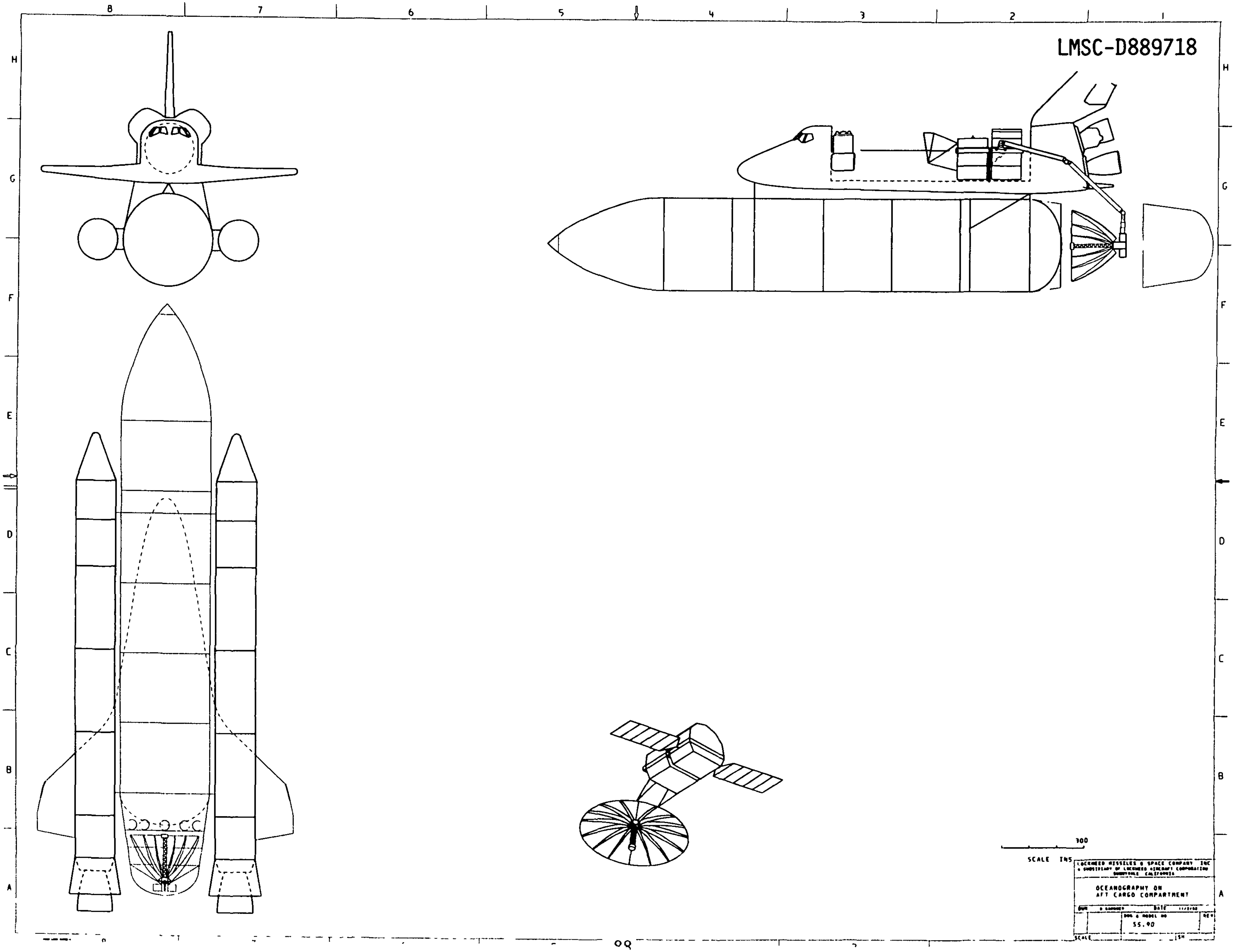

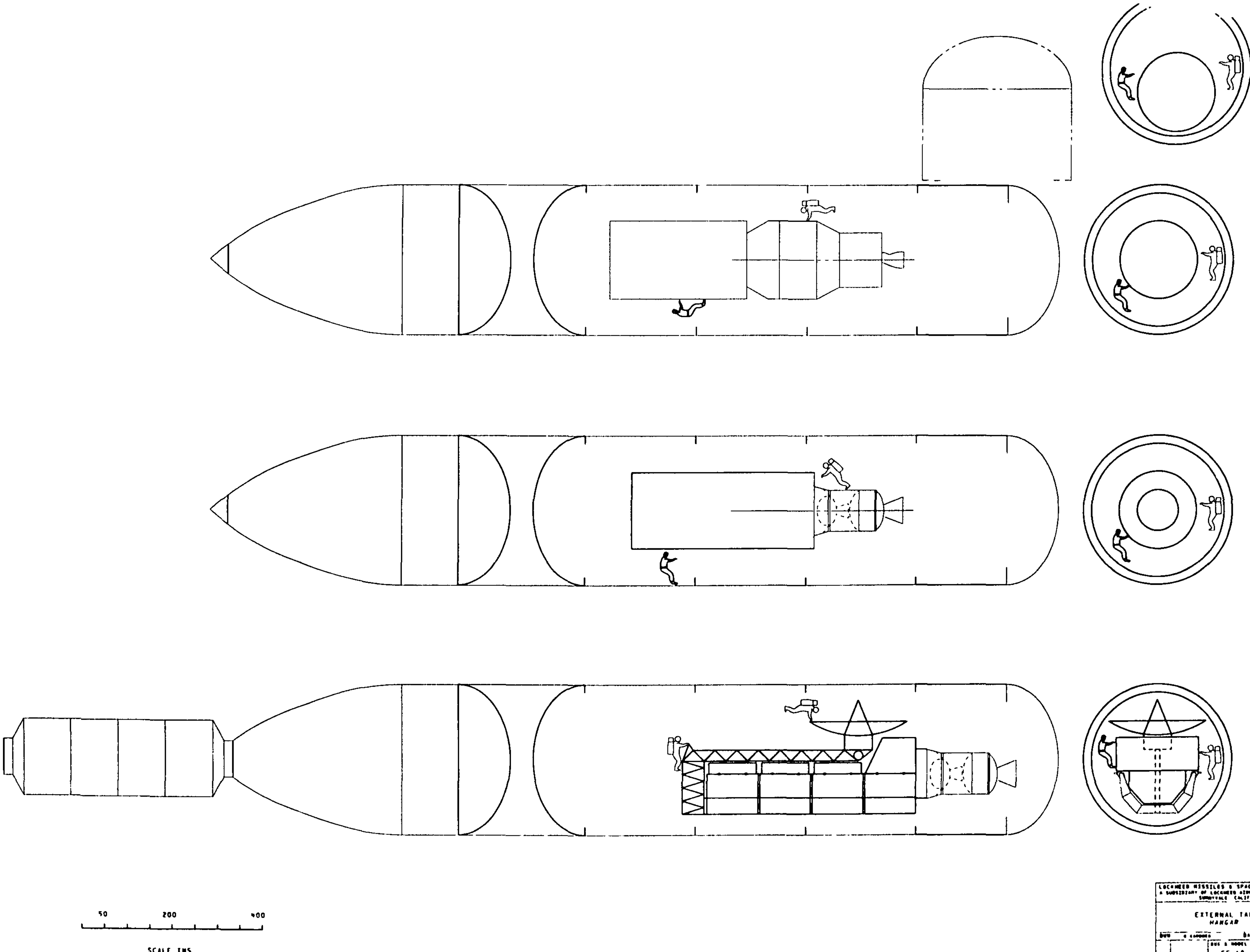

LOCKHEED MISSILES & SPACE COMPANY, INC
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SUNNYVALE CALIFORNIA

EXTERNAL TANK
HANGAR

SS 68

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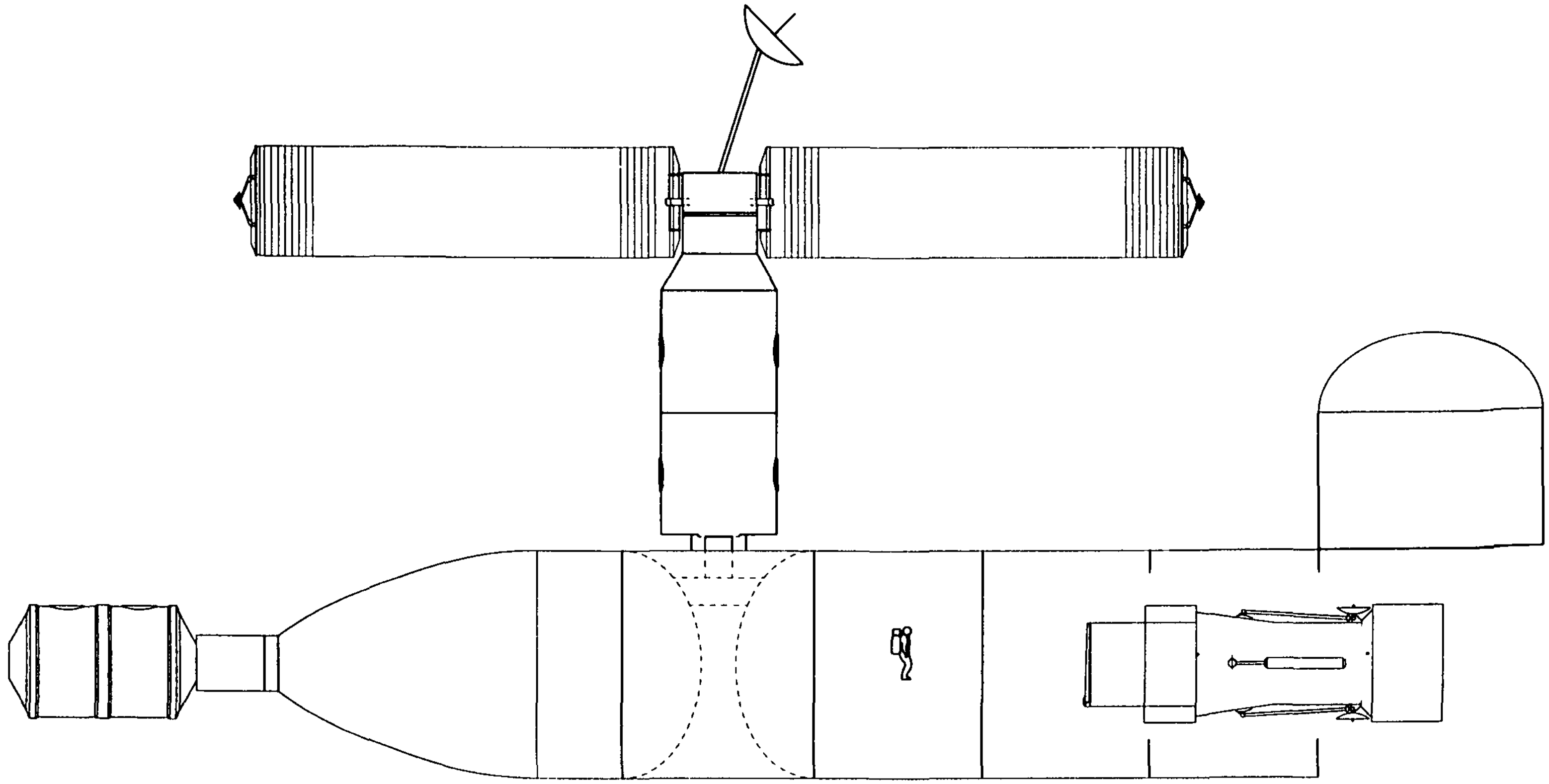

LOCKHEED MISSILES & SPACE COMPANY INC
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SUNNYVALE CALIFORNIA

SS LAYOUT
ET CONCEPT

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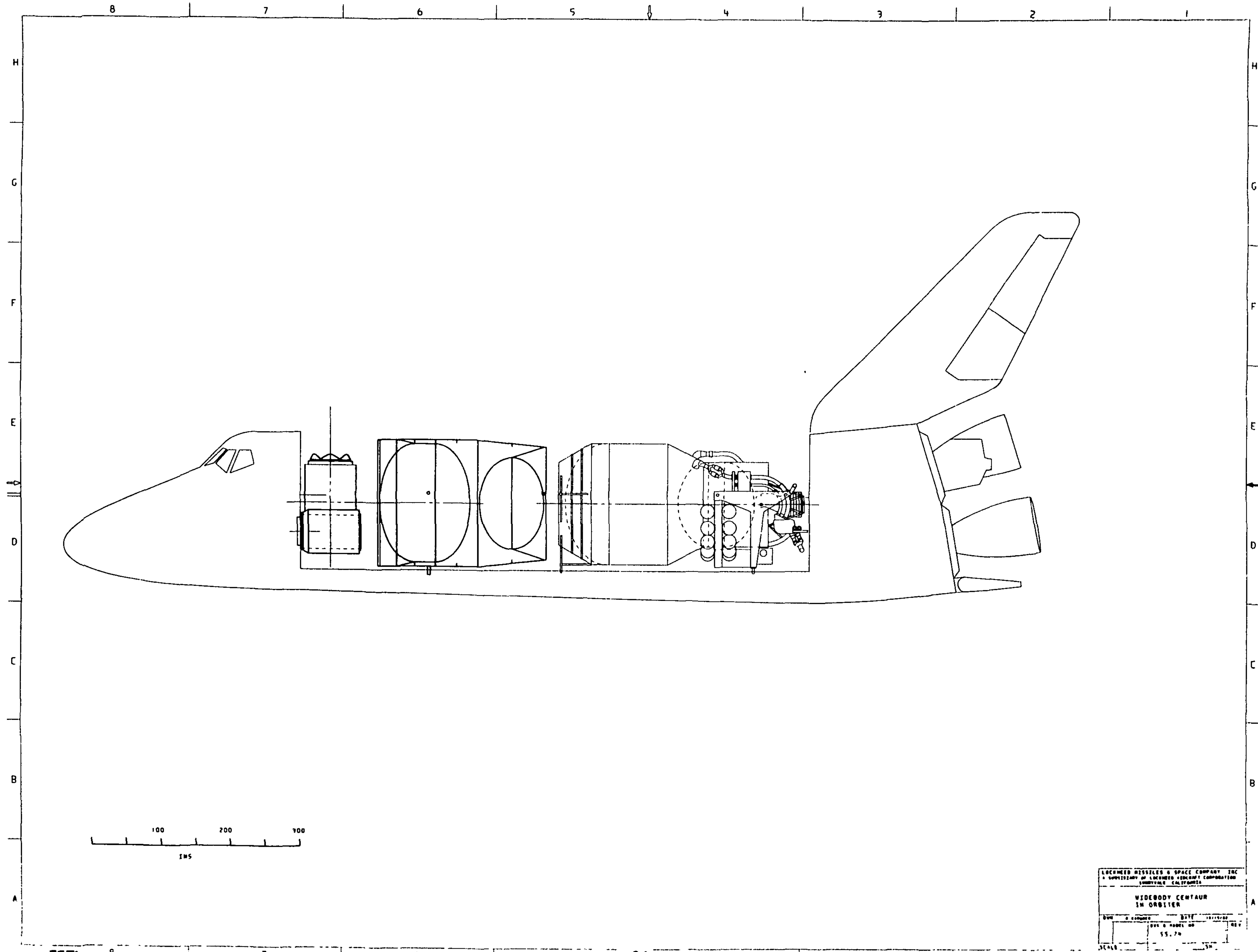
SCALE | SH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LOCKHEED MISSILES & SPACE COMPANY INC
SUNNYVALE CALIFORNIA
WIDEBODY CENTAUR
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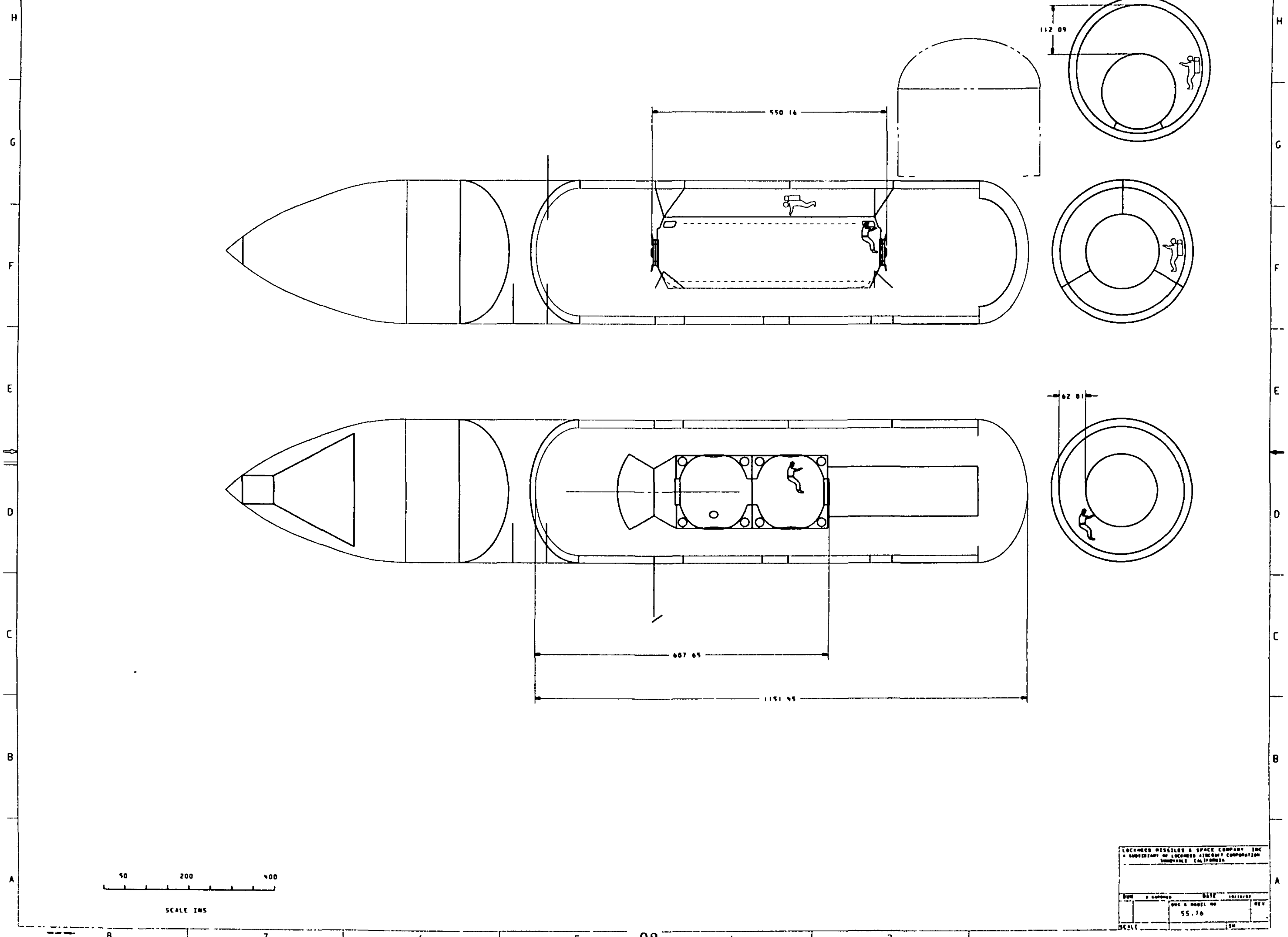
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LOCKHEED MISSILES & SPACE COMPANY INC
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE CALIFORNIA
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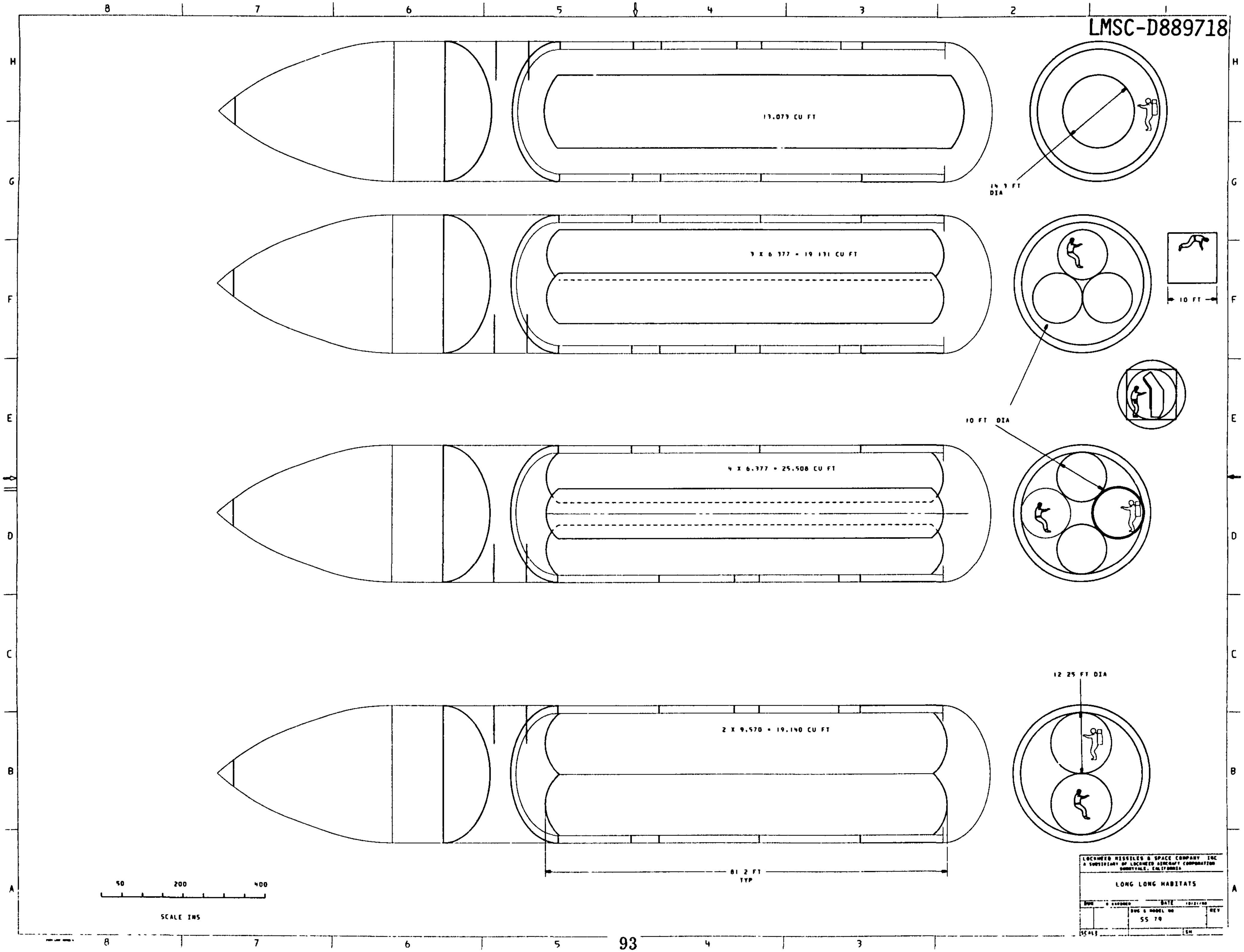
13,079 CU FT
14.9 FT DIA
3 X 6,377 = 19,131 CU FT
10 FT
10 FT DIA
4 X 6,377 = 25,508 CU FT
12.25 FT DIA
2 X 9,570 = 19,140 CU FT
81.2 FT TYP
50
200
400
SCALE INS
LOCKHEED MISSILES & SPACE COMPANY INC
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SUNNYVALE, CALIFORNIA
LONG LONG HABITATS
DATE
DWG & MODEL NO
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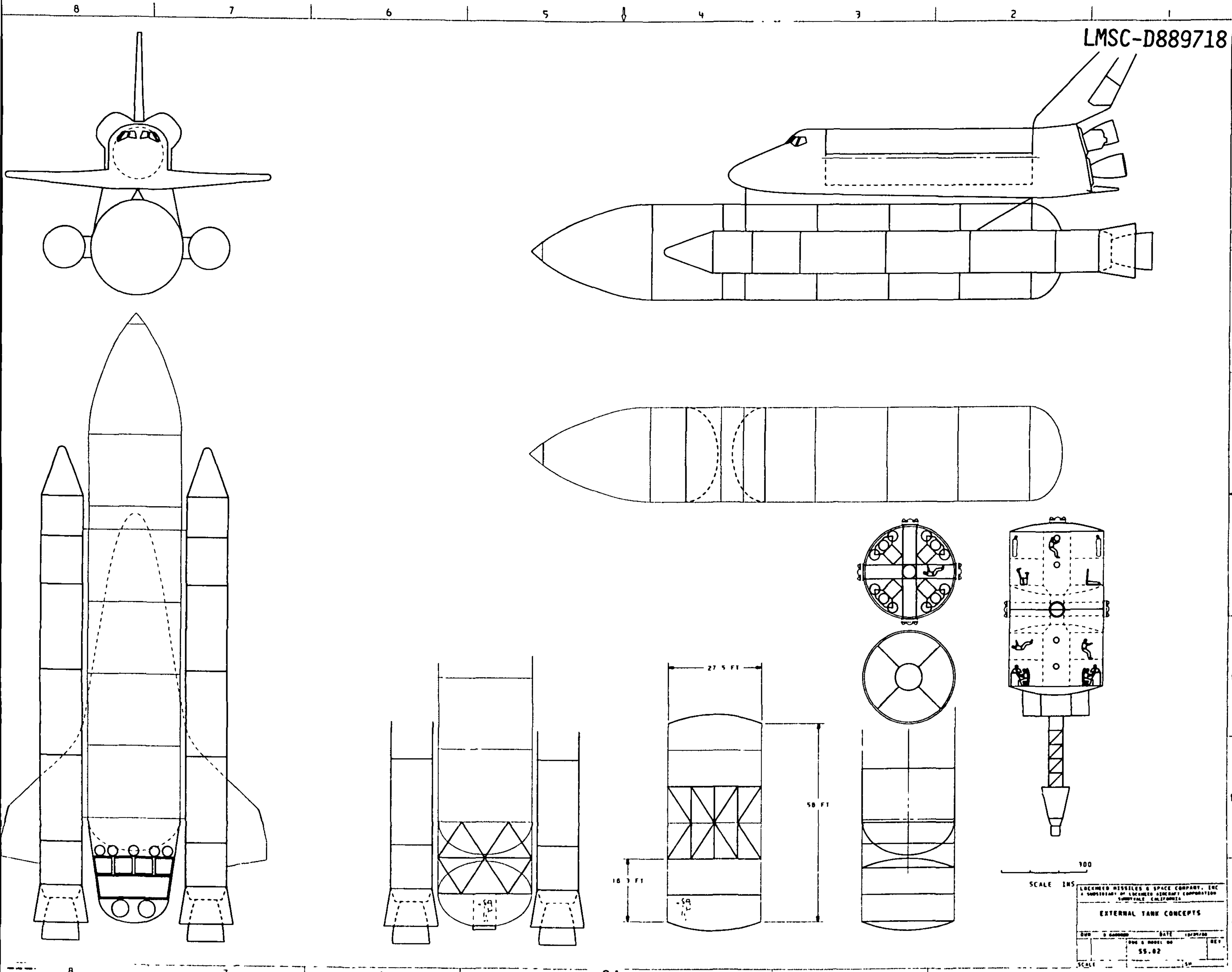
27.5 FT
58 FT
18.7 FT
100
SCALE INS
LOCKHEED MISSILES & SPACE COMPANY, INC
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SUNNYVALE CALIFORNIA
EXTERNAL TANK CONCEPTS
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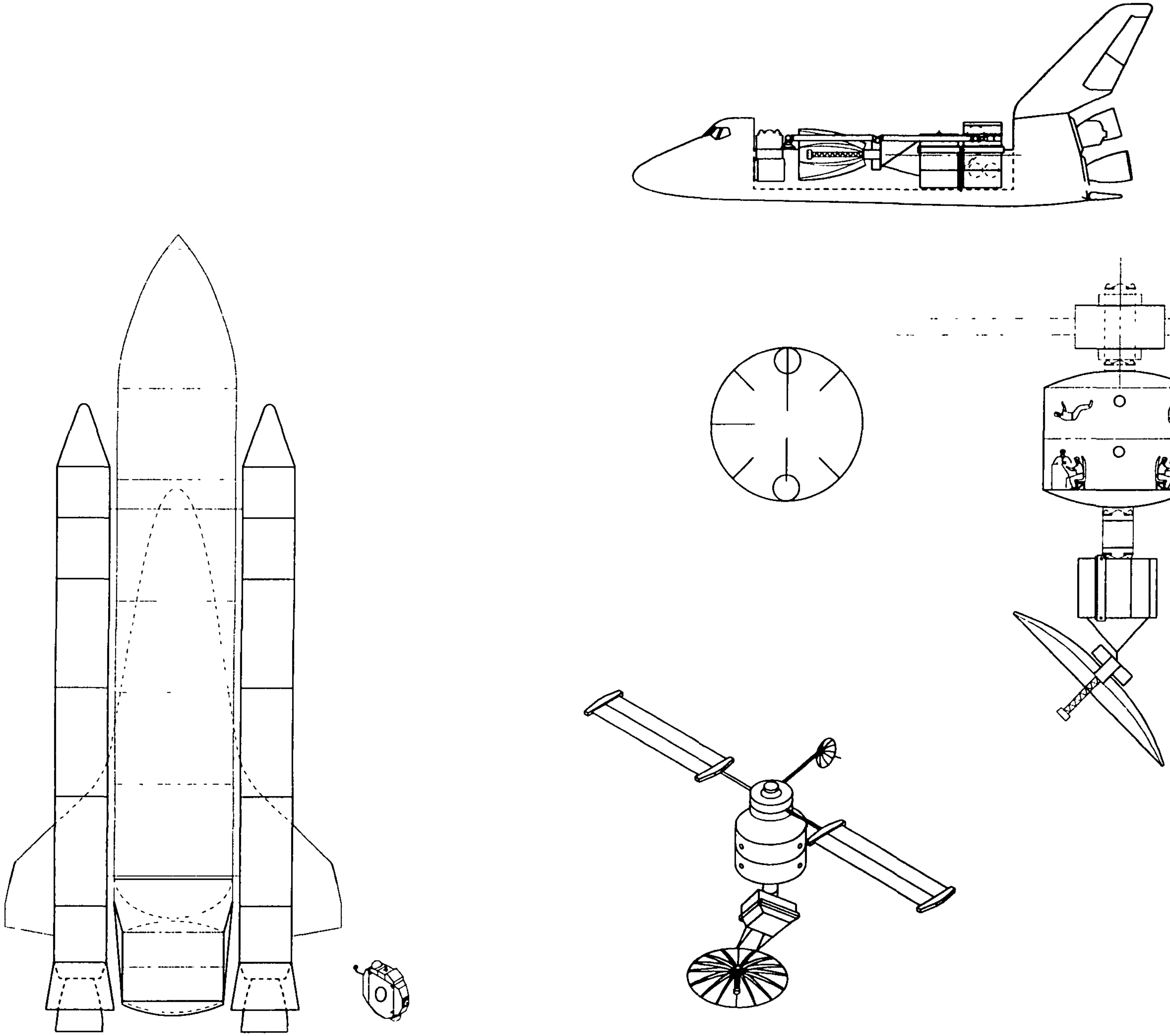

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SPACE STATION PROGRAMS

ATTACHMENT 2

SUPPORTING DATA AND ANALYSIS REPORTS

VOLUME II

EVA TECHNOLOGY NEEDS

Lockheed

EVA TECHNOLOGY NEEDS

Presentation To

SPACE STATION TECHNOLOGY WORKSHOP

CREW & LIFE SUPPORT PANEL

Mr. Walter Guy, Chairman

28 MARCH 1983

H. T. Fisher

Crew Systems Supervisor

Lockheed Missiles & Space Company

PRESENTATION OBJECTIVES

A. TO PRESENT A GENERAL OVERVIEW OF CURRENT EVA TECHNOLOGY RELATIVE TO A SELECTED COMPLEMENT OF SPACECRAFT

B. TO REVIEW CERTAIN GROUNDRULES & GUIDELINES FOR DESIGN OF SPACECRAFT TO FACILITATE EVA SERVICING

C. TO DISCUSS LESSONS LEARNED RELATIVE TO THE 'SELECTED' SPACECRAFT

D. TO IDENTIFY THE CURRENT TO MID/LATE 1980's EVA EQUIP & SUPPORT HARDWARE 'DEVELOPMENT STATUS'

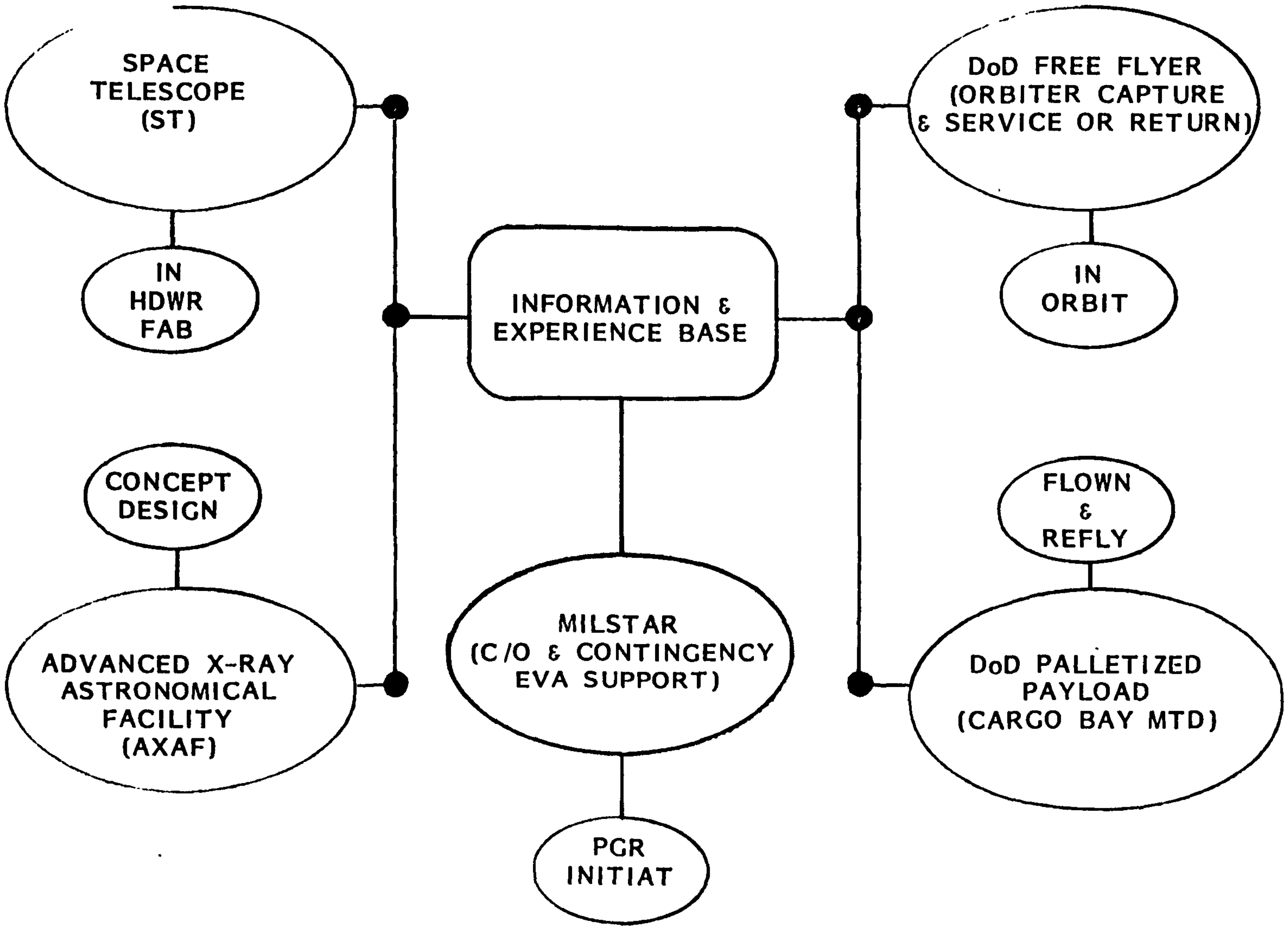
E. TO PRESENT GENERAL RELATIONSHIPS OF SERVICING FROM SHUTTLE VS SPACE STATION

F. TO IDENTIFY TECHNOLOGY TRANSFER FROM THE 1980s TO THE STATION & SELECTED NEW TECHNOLOGY SERVICING/HDWR CONCEPTS FOR THE 1990s

Pages Missing From Available Version:

Even numbers from 100 to 148

EVA REQTS - EXAMPLE TECHNOLOGY BASE



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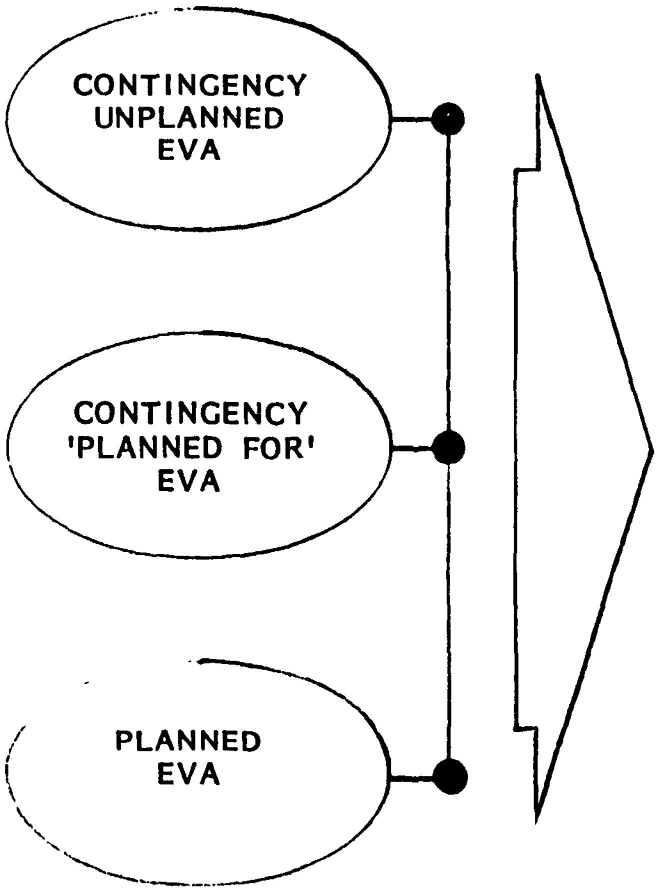
EVA & SERVICING CATEGORIES



SERVICING/MAINTENANCE FUNCTIONAL REQTS

A. INSPECT/EXAMINE/ASSESS

B. SAFEING

C. CONSUMABLES REPLENISHMENT

D. ORBITAL REPLACEMENT UNIT (ORU) CHANGEOUT

   1. FAILED/DEGRADED ITEM
   2. NEW/UPDATED ITEM
   3. PREVENTATIVE MAINT ITEM

E. RECONFIGURE

F. REPAIR

G. GENERAL SERVICE/ENHANCEMENT OPS

H. DEBRIS CAPTURE/CONTAINMT/XFER

I. PREPARE ITEM FOR DE-ORBIT

J. CHECKOUT & VERIFY

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SERVICING/MAINT REQTS & EVA TASKS

SERVICING/MAINTENANCE FUNCTIONAL REQTS

A. INSPECT/EXAMINE/ASSESS
B. SAFEING
C. CONSUMABLES REPLENISHMENT
D. ORBITAL REPLACEMENT UNIT (ORU) CHANGEOUT
   1. FAILED/DEGRADED ITEM
   2. NEW/UPDATED ITEM
   3. PREVENTATIVE MAINT ITEM
E. RECONFIGURE
F. REPAIR
G. GENERAL SERVICE/ENHANCEMENT OPS
H. DEBRIS CAPTURE/CONTAINMT/XFER
I. PREPARE ITEM FOR DE-ORBIT
J. CHECKOUT & VERIFY

EQUIPMT UTILIZATION

1. HAND TOOL USE
2. EQUIP SET-UP/TEAR-DWN
3. ENG/DISENG TETHER
4. MOUNT/DEMOUNT LGHT
5. MATE/DEMATE CONNECT
6. CABLE/HARN GRASP
7. ORU HANDLING
8. MECH ACTUATION
9. HAND HOLD/HAND RAIL I/F
10. ETC

OBJECT SIZE

- SMALL = 1 CU FT
- MED = 15" X 20" X 30"
- LARGE:
  - 'TELE BOOTH'
  - 20" X 80" X 60"
- UNIQUE = 18' X 1.5'

TASK ACT

- ENG/DISENG
- MANIP SM OBJECT
- REM/REPL
- INSERT/WITHDRAW
- PUSH-PULL
- ALIGN
- FASTEN
- APPLY STEADY CONTIN FORCE
- DECELERATE ITEM
- PROVIDE WHOLE ARM & SHLDR TORQUE
- EXTEND/RETRACT
- OPEN/CLOSE
- ACTUATE LOCK DEV
- TURN VALVE
- PULL CABLE

SERVICING EQUIP EVOLUTION PROCESS

SSE EQUIP. DEFINITION, EVALUATION, AND SUBSTANTIATION

PRIMARY DRIVERS

- ACCESSIBILITY
- OBSERVATION/VIEWING
- EQUIP UTILIZATION
- TOOLS AND AIDS
- INTERFACES
- S/C CONFIGURATION
- ORBITER SERVICES
- SUPPORT HARDWARE
- CREW FUNCTIONS
- SAFETY
- DEPLOY/BERTH/DOCK
- TIMELINES

- DEPLOYMENT
- RETRIEVAL
- SUPPORT
- OBSERVATION
- EARTH RETURN

SERVICE EQUIPMENT DEFINITION

EVALUATION CRITERIA (REPRESENTATIVE)

CREW INTERFACE
- FLIGHT CREW OBSERVATION
- CLOSE RESCUE ROUTE
- MINIMUM CREW/EQUIP TRANSLATION
- WORK PLATFORM COMPLEMENT
- CABLE/UMBILICAL MATE/DEMATE.
- EASE OF DOCKING/BERTHING
- EXISTING CREW WINDOW USE

SHUTTLE ORBITER
- PALLET PROXIMITY TO AIRLOCK
- PALLET PROXIMITY TO SERVICE PANEL
- ORBITER-SV UMBILICAL LENGTH

RMS UTILIZATION AND SERVICE
- ACCESS WITH/WITHOUT APPENDAGES DEPLOYED
- CREW/EQUIPMENT TRANSFER
- UMBILICAL MATE/DEMATE
- DEPLOYMENT/RETRACTION OF APPENDAGES
- POSITIONING SV FOR BERTHING/DOCKING

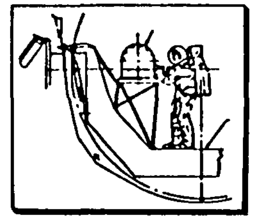
P/L BAY CLEARANCE
- SV LENGTH
- SOLAR ARRAYS
- ANTENNA
- PALLET (WORK PLATFORM)
- OMS KIT
- CREW COMPARTMENT
- AFT ORBITER SECTION

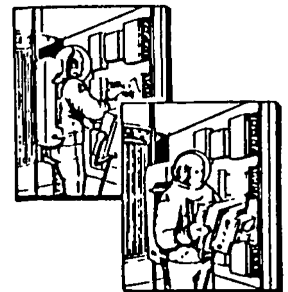
WORK PLATFORM
- UTILIZATION POTENTIAL
- P/L BAY LOCATION
- BERTHING/DOCKING INTERFERENCE
- CABLE/UMBILICATION INCORPORATION

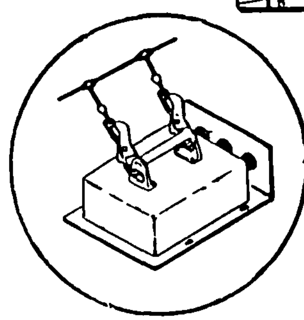
BERTHING/DOCKING OPERATIONS AND POSITION
- CREW VISION DURING DOCKING
- MULTIPLE POSITIONS DURING DEPLOYMENT
- REMOTE MANIPULATOR UTILIZATION
- ACCESSIBILITY
- BERTHING/DOCKING MECHANISM COMPLEXITY
- BERTHING/DOCKING MECHANISM WEIGHT/VOLUME
- ACCEPTABILITY OF APPROACH TO NASA

APPENDAGE DEPLOYMENT/RETRACT
- ANTENNA POSITIONS
- SOLAR ARRAY POSITIONS
- INTERFERENCE FACTORS
- RADIATOR INTERFERENCE

CONTINGENCY
- PAYLOAD BAY OBSTRUCTIONS, e g., OMS KIT
- MINIMAL RETRIEVE/DEPLOY OPERATIONS
- CREW PROXIMITY TO AIRLOCK FOR RESCUE
- SV INSERTABLE INTO P/L BAY WITH RMS FAILURE







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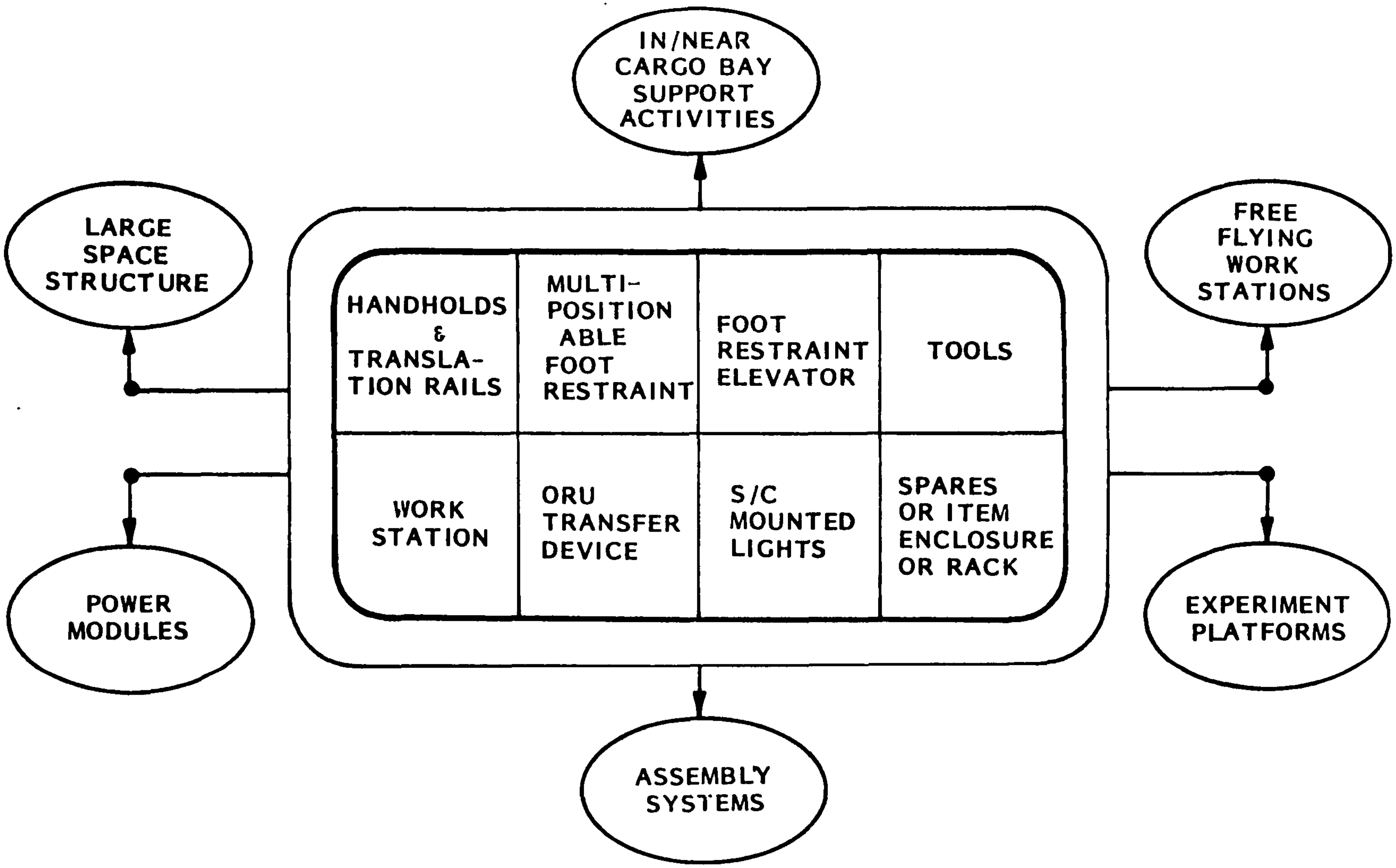
EVA AIDS GENERIC APPLICABILITY



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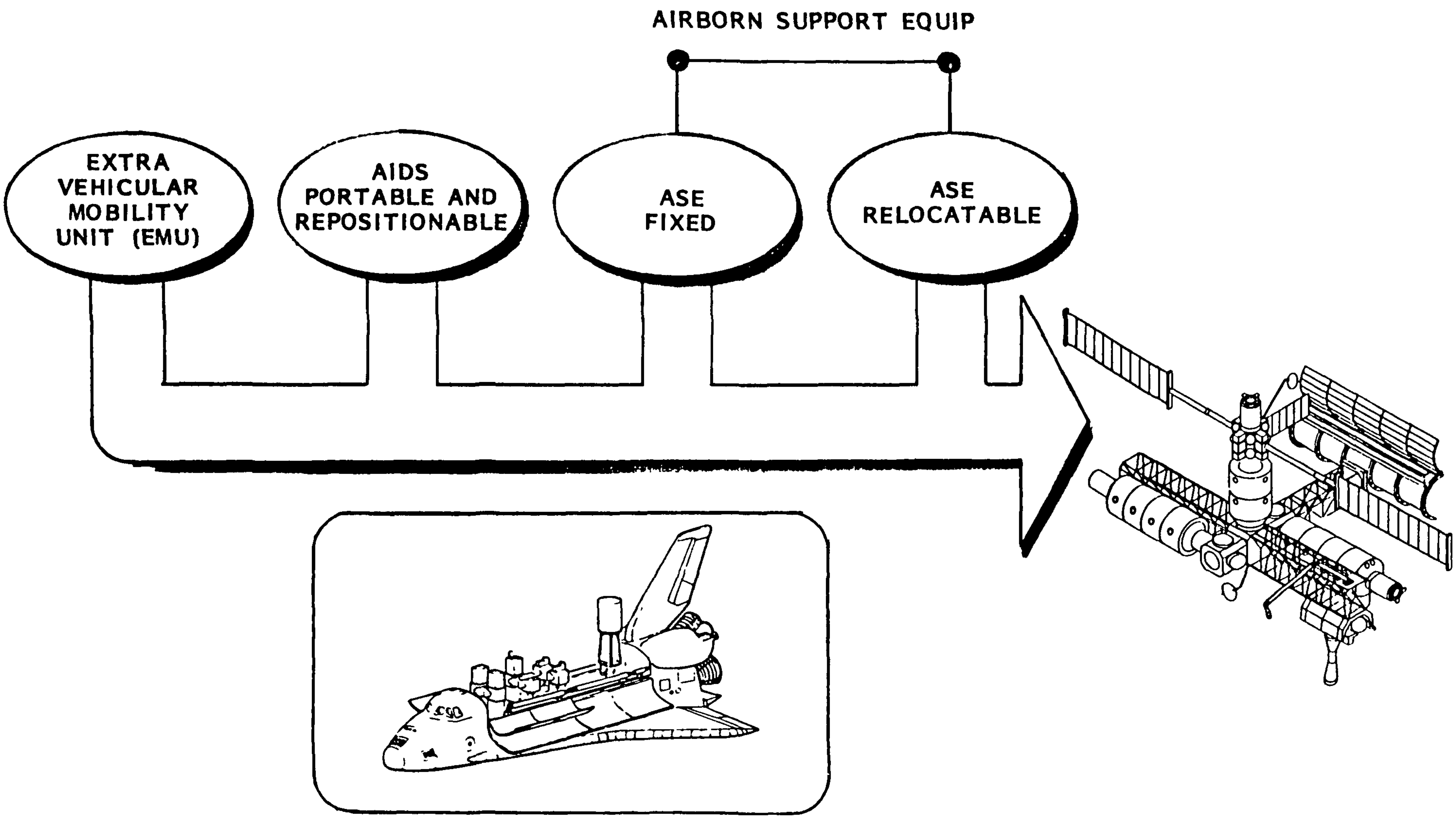
EVA SYSTEM & SUPPORT HDWR (PRESENT & NEAR TERM)



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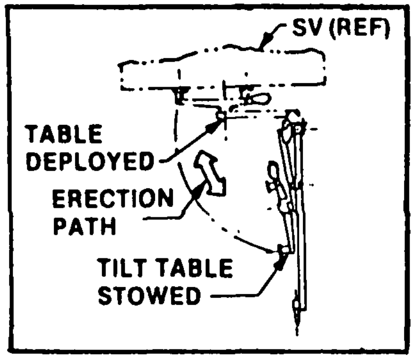
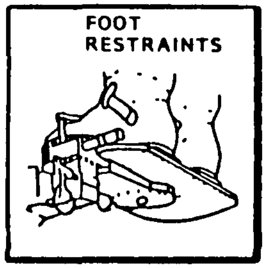
P/L SERVICING - LESSONS LEARNED



1. ROTATION (±180) AND PIVOT (UP TO 90^{o}) BERTHING DEVICE LED TO;

   A. REDUCED SPACE SUPPORT EQUIPMENT
   B. REDUCED EVA TIMELINES
   C. FLEXIBILITY IN RMS-GRAPPLE FIXTURE LOCATIONS
   D. FLEXIBILITY IN SPARES CONTAINER POSITIONING IN CARGO BAY
   E. MORE SIMPLIFIED LARGE ITEM CHANGEOUT
   F. POTENTIAL FOR ELIMINATING RMS EXTRAC/INSERT OF P/L OUT OF OR INTO CARGO BAY

2. BASIC APOLLO/SKYLAB FOOT RESTRAINT REQUIRED BUILT-IN ARTICULATION FEATURES



   A. SINGLE FIXED POSITION INADEQUATE
   B. FULL RANGE OF CREW MOTIONS COULD BE BETTER UTILIZED
   C. GREATER RANGE OF ASTRONAULT 'SIZE' (MALE & FEMALE) ACCOMMODATIONS REQD
   D. REDUCES NEED FOR ADDED SSE & CREW AIDS
   E. REDUCES NEED FOR ADDED OR MORE COMPLEX P/L EQUIPMENT DESIGN
   F. ALLOWS FOR LESS 'OPEN' AND SWEPT VOLUME AREA IN P/L

3. DESIGN FOR 5TH 95TH PERCENT TILE FEMALE CREW MEMBER NOT A TREMENDOUS IMPACT

   A. FORCE 'INPUTS' OR 'LOADS' CAN BE RESTRICTED TO 25 FT. LBS.
   B. ELEVATION DEVICE ON FOOT RESTRAINT OVERCOMES HEIGHT ADJUSTMENT PROBLEM
   C. INTERNAL 'CAVITY' REACH DISTANCE (5TH PERCENT TILE) IS A PROBLEM BUT CAN BE OVERCOME EARLY IN DESIGN
   D. LARGE & 'HEAVY' ITEM TRANSFER MASS HANDLING CONCERN DESIGNED-OUT VIA TRANSFER RAILS AND PROCEDURALLY DIRECTED MOVEMENT RATES
   E. DESIGN FOR '0-G LAYOUT' CAN FURTHER ACCOMMODATE SIZE DIFFERENTIALS
   F. EARLY DESIGN REQT INPUT CAN ALIEVIATE MANY ANTHROPOMETRIC PROBLEMS

P/L SERVICING - LESSONS LEARNED
(CONT'D)

4. MINIMUM TOOLS CAN BE ACHIEVED IN DESIGN FOR P/L SERVICING

A. RATCHET WRENCH (7/16 IN. SOCKET) CAN DO NEARLY ALL JOBS

- ALL INSTALLATION 'FASTENERS' CAN BE STANDARDIZED TO 7/16 IN. HEX HEADS (WITH ALLEN INSERT IF DESIRED)
- TWO EXTENSIONS (10 IN. AND 22 IN.) HIGHLY DESIRABLE (MAY BE PERMANENTLY MOUNTED TO WRENCH THUS REQUIRING 2 WRENCHES)
- TORQUE LIMITER (BUILT-IN) REQUIRED
- HANDLE SIZE SHAPE MOD REQUIRED
- RATCHET DIRECTION 'LEVER' MOD. REQUIRED
- TETHER RING (360° ROTATABLE) REQUIRED

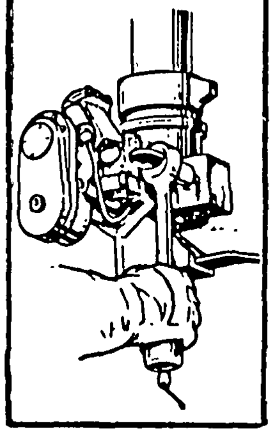
B. POWER WRENCH REQUIRED FOR CERTAIN TASKS

- REVERSE FORCE APPLICATION REQUIRED
- TORQUE LIMITER (BUILT-IN) REQUIRED
- CORDLESS UNIT HIGHLY PREFERABLE
- HANDLE DESIGN REQUIRED TO ACCOMMODATE 5% TILE FEMALE CREW PERSON
- TETHER REQUIRED AND EASILY OPERATED 'DIRECTION' CONTROL NEEDED
- RUNNING TIME OF UP TO 2.5 HOURS VERY DESIRABLE IF CORDLESS UNIT

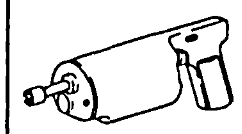
C. ILLUMINATION DEVICE REQUIREMENT STILL NOT FULLY KNOWN

- NO EXPERIENCE YET WITH SHUTTLE EMU HELMET MOUNTED LIGHTS
- DETAILED INTERIOR P/L LIGHTING STUDY REQUIRED TO EVOLVE SPECIFIC LOCATIONS, CONES, BRIGHTNESS LEVELS, REFLECTION PATTERNS, ETC.
- APPEARS TO BE AN EVOLVING NEED FOR A PORTABLE, BATTERY OPERATED, TEMPORARY POSITIONABLE UNIT TO ALIGNMENT SELECTED EVA TASKS

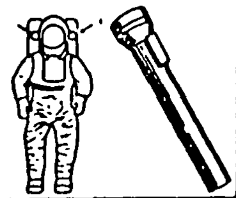
EXTEND/RETRACT MOTOR OVERRIDE



POWER TOOL



HELMET LIGHT AND PORTABLE LIGHTS



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P/L SERVICING - LESSONS LEARNED

(CONT'D)

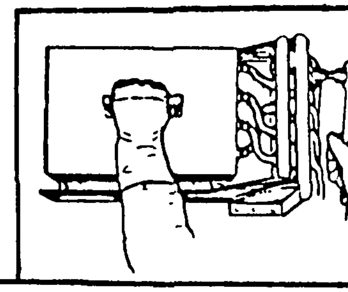
5. REPLACEABLE ITEMS ON-ORBIT

A. IF PROPERLY RESTRAINED, SIMULATIONS INDICATE ITEMS AS LARGE AS A TELEPHONE BOOTH ARE NO MAJOR PROBLEM

B. EQUIPMENT ITEMS WITH 2 OR LESS CONNECTORS MOST OFTEN CAN ACCOMMODATE EVA MANUALLY MATED/DEMATED 'WING-TAB' CONNECTORS

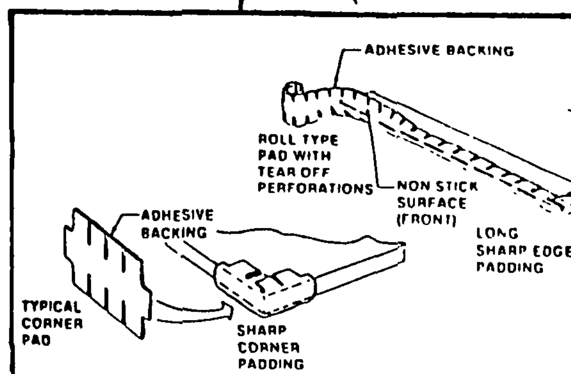
C. NEW APPROACH REQUIRED FOR CONNECTOR MATE/DEMATE WHEN CONNECTORS CLOSELY SPACED

- GLOVED CONNECTOR OPERATIONS ELIMINATED
- NO CABLE FLEXING
- VISUAL CONFIRMATION OF CONNECTOR ENGAGE/DISENGAGE
- REDUCED TIMELINES
- SINGLE TOOL (7/16 IN. RATCHET WRENCH) INTERFACE
- POSITIVE ORU INSTALLATION INDEXING
- EASY FASTENER-TOOL INTERACTION
- ADAPTABLE UP TO 22 OR MORE CONNECTORS



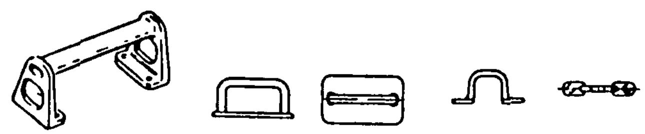
D. CORNERS/EDGES (EVA CRITERIA) A MAJOR IMPACT

- OFF-SHELF ITEMS
- MIN. EXTERNAL COVER THICKNESS
- BOX REQUALIFICATION POTENTIAL
- 'ACCEPTABLE' CRITERIA



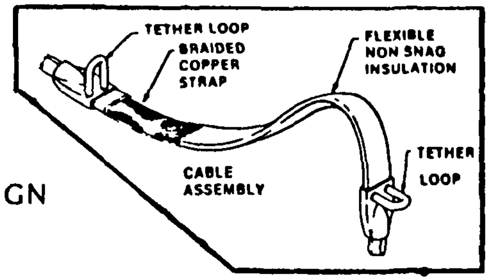
E. NO BLIND CONNECTORS - MAJOR 'BATTLE'

F. IMPACT OF TETHER RINGS AND HANDHOLDS - WHERE, SPACE ALLOCATION, STRUCTURE BEEF-UP, ETC.



P/L SERVICING – LESSONS LEARNED (CONT'D)

5. (CONT'D)



G. IMPACT OF GROUNDING STRAPS

- USUALLY 'FORGOTTEN' UNTIL WELL INTO CRITICAL DESIGN
- LOCATION, HANDLING

H. CABLE 'MANAGEMENT' PROBLEM

- USUALLY NOT CONSIDERED EARLY ENOUGH IN DESIGN LAYOUTS
- REQUIRES ADDED 'CREW AIDS'

I. CONNECTOR INDEXING

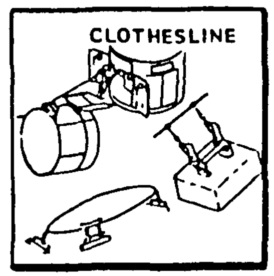
- THERE IS A DESIRED CONNECTOR MATED POSITION ORIENTATION
- CONNECTOR MATED POSITION CUES

J. MULTI-LAYER INSULATION (MLI) COVERING

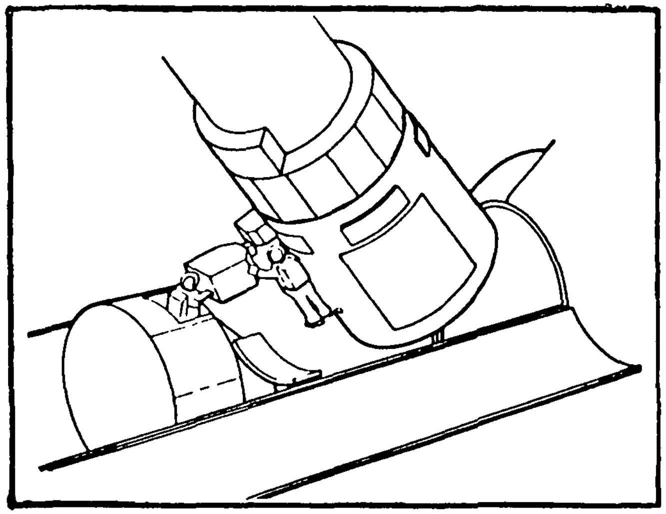
- FRAGIL/SURFACE DAMAGE POTENTIAL
- ENVELOPE IMPACT

K. ITEM TRANSFER

- CLOTHESLINE APPROACH APPEARS PRACTICAL
- PERMITS 2-CREW TEAM COOPERATIVE EFFORT
- LOW COST
- LOW WEIGHT/STOWAGE
- HIGHLY VERSITLE/FLEXIBLE



P/L SERVICING - LESSONS LEARNED (CONT'D)



6. CREW INDUCED LOADS

   A. REQUIRES VERY EARLY DEFINITION
   B. PRODUCED MAJOR IMPACT ON 1 P/L IN PARTICULAR
   C. DESIGN SAFETY FACTOR OF 3 IS SIGNIFICANT

      - ALSO DESIGN TO LIMIT VS. YIELD

7. SIMULATION

   A. 1-G SUITED SIMULATION HIGHLY EFFECTIVE

      - STATIONARY TASKS
      - MIN. 'BACKWARD' LEANING
      - MIN. 'SIDE' LEANING
      - UPRIGHT BODY
      - ADEQUATE FOR 'ICD' PREPARATION
      - REQUIRES 'ARTICULATING' FOOT RESTRAINT WITH ELEVATION

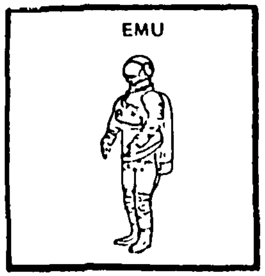
   B. SUITED UNDERWATER SIMULATION HIGHLY EFFECTIVE

      - TASKS REQUIRING SIGNIFICANT TRANSLATION
      - TASKS NECESSITATING MAJOR BODY MOVEMENT AND NON-UPRIGHT BODY POSITION
      - UNRESTRAINED (BUT TETHERED) MOVEMENT OF LARGE OBJECTS
      - LEARNING OF WEIGHTLESS EFFECT ON TASK

8. SHUTTLE EMU DATA CRITICAL TO DESIGN

   A. APOLLO A7 LB SUIT MAY NOT BE CHARACTERISTIC OF SHUTTLE SUIT
   B. LATE INCORPORATION OF SHUTTLE EMU ANTHROPMETRICS:

      - MAY IMPACT DESIGN
      - MAY INVALIDATE EXISTING TIME-LINES AND SIM. RESULTS
      - MAY RESULT IN SUBMITTAL OF COSTLY ECP's



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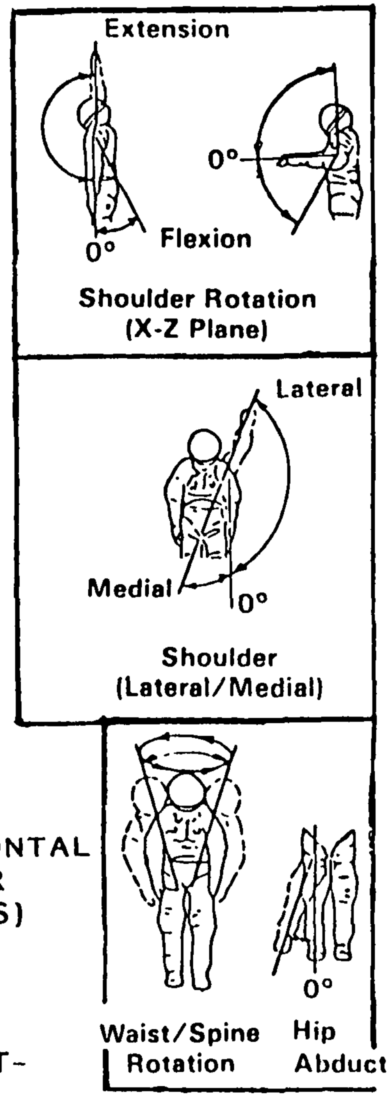
SUIT MOBILITY - UTILIZATION RANGES

1. NEARLY ALL TAKS CONDUCTED ABOVE WAISTLINE
2. SPECIFIC REACH ZONES ARE:
   - A. DESIGNED WITHIN A VERTICAL 24 IN. ENVELOPE
   - B. SOME TASKS REQUIRE REACH UP TO 30^{o} ABOVE HORIZONTAL
     - TASKS INCLUDE CONNECTOR MATE/DEMATE AND ORU POSITIONING
     - EYE/HAND COORDINATION REQUIRED
     - CREWPERSON IS VOLUMETRICALLY BOUNDED BY STRUCTURE
   - C. INTERNAL CAVITY (E.G., EQUIP. BAY) ACCESS
     - FULL REACH DEPTH REQUIRED
     - CHEST PAK AND 'TOOL CADIE' RESTRICT REACH DEPTH
3. SUIT MOTION
   - A. CERTAIN TASKS RESULTED IN:
     - 'LEANING' SIDE TO SIDE WHILE REACHING UP TO 30^{o} ABOVE HORIZONTAL
     - 'LEARNING' FULL BACKWARD WHILE CLOSING EQUIP. SECTION DOOR
     - REMOVING 1 FOOT FROM FOOT RESTRAINT AND LEANING (SIDEWAYS) TOWARD WORK SITE
   - B. BODY FATIGUE
     - SHOULDER AND UPPER ARM FATIGUE NOTED IN SUBJECTS CONDUCTING REACH (EXTENDED) HELMET LEVEL (OR HIGHER) TASKS



CURRENT TECHNOLOGY (HDWR) STATE-OF-ART

EQUIPMT FEATURES FOR ON-ORBIT CHANGEOUT/OVERRIDE	FLIGHT HARDWARE NASA	FLIGHT HARDWARE DoD
• INSTALL/REMOVE TECHNIQUES-SMALL (> 1 CU FT) TO BIG (< 52 CU FT)	FD	PD/P
• COMPONENT/SUB-MODULE/MODULE MOUNTING TECHNIQUES	FD/F	FD/F
• CONNECTOR MATE/DEMATE-MANUAL/RACK/AUTOMATED	FA	FD
• CONNECTOR TYPES & EVA PROVISIONS	FA →	AVAIL
• CONNECTOR & GROUNDING STRAP HANDLING TECHNIQUES	FD/FA	FD/F
• MULTIPLE (MORE THAN 3 PER BOX) CONNECTOR I/F TECHNIQUES	FD/F	FD
• ROUND CORNER/EDGE CRITERIA & 'FIXES'	F/FA	FD
• UNIVERSAL 'CAST' LOW COST HANDHOLDS	FA →	AVAIL
• UNIVERSAL 'CAST' LOW COST TETHER RINGS	FA →	AVAIL
• MECHANICAL TIE-DOWN FASTENERS (EVA-TOOL COMPATIBLE)	FD/FA →	AVAIL
• PANEL-DOOR FASTENERS (LOAD & NON-LOAD CARRYING)	FD/F	-
• PANEL-DOOR HINGE & 'STAY-OPEN' DEVICES	FD/F	-
• THERMAL & GROUNDING I/F TECHNIQUES	FD/F	PD/P
• MOUNTING RAIL TECHNIQUES (EQUIP REMOVE/REPLACE)	FD	-
• VERY-HIGH TOLERANCE (13 SEC OF ARC) EVA ALIGNMT MTG TECHNIQUES	FD/F	-
• RACK & PANEL INSTALLATION ALIGNMENT TECHNIQUES	FD/P	P
• APPENDAGE/BOOM SEPARATION DEVICES	FD/F	FD/P
• APPENDAGE BOOM MECHANISMS & EVA-TOOL OVERRIDE TECHNIQUES	FD/F	
• EVA XLATION RAILS & MOUNTING FEATURES FOR S/C	FD	
• FOOT RESTRAINT RECEPTACLES & S/C MOUNTING I/F FEATURES		
• MULTI-POSITIONABLE (ROLL/YAW/PITCH) FOOT RESTRAINT (NO HAND OPS)		
• EVA TORQUE-RATCHET WRENCH		
• FOOT RESTRAI		

FD = FINAL DESIGN | F = FABRICATION | FA = FLIGHT ARTICLE | P = PROTOTYPE | PD = PRELIM DESIGN

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EVA SERVICING MAINTENANCE HDWR – TECHNOLOGY BASE

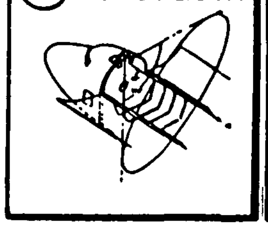
CURRENTLY AVAILABLE

DEVELOPMENT NEED / EVA AIDS*	NO NEW DEV REQD	ADDED DEV REQD	EXAMPLE SERVICING BASE USED
1. EMU		●	◀
2. MMU		●	
3. EVA HAND HOLDS	●		◀
4. EVA HANDRAILS	●		◀
5. TETHERS	●		◀
6. SELF-TENDING TETHER	●		◀
7. TETHER RINGS	●		◀
8. FOOT RESTRAINT	●	●	◀
9. FOOT RESTRAINT RECP		●	
10. MINI-WORK STA		●	
11. MESA-MODIFIED	●		
12. TOOL CADDY	●		◀
13. ORBITER HAND TOOLS		●	◀
14. HELMET MTD LIGHTS	◑		◀
15. TILE KIT-STOW ASSY	◑		
16. ETC			

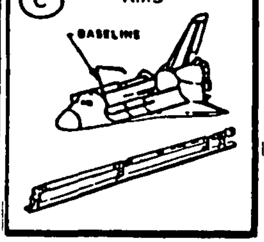
CURRENTLY AVAILABLE

EXAMPLE SERVICING BASE USED	DEVELMT NEED / ORB EVA AIDS*	NO NEW DEV REQD	ADDED DEV REQD
▶	1. RMS		●
▶	2. SLIDE WIRE	●	
▶	3. HAND HOLDS	●	
▶	4. HAND RAILS	●	
▶	5. HATCH MECH	●	
▶	6. CONNECTORS	●	
	7. HNG OVRD MECH		
▶	8. EVA LIGHTS		●
	9. CCTV	●	
	10. ETC		

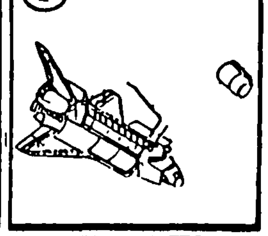
(R) ORBITER LIGHTS



(C) RMS

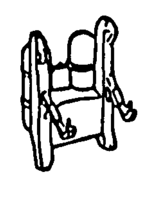


(E) EVA HANDRAILS

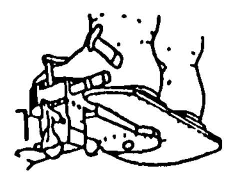


(A) EMU

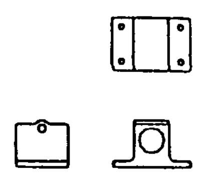
(B) MMU



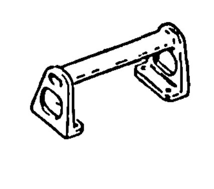
(K) FOOT RESTRAINTS



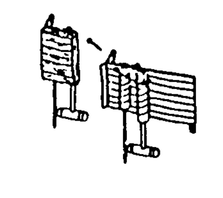
(L) FOOT RESTRAINT RECEPTACLES



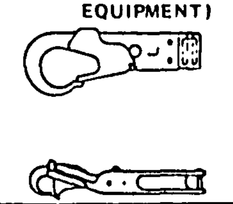
(D) EVA HANDHOLDS



(O) TOOL CADDY



(H) TETHERS (PERSONAL/ EQUIPMENT)



◑ = QUESTIONABLE NEW DEV NEED

* = STATION APPLICABLE

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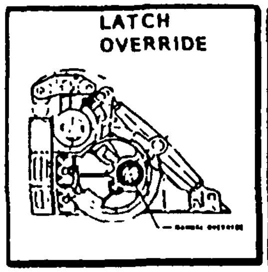
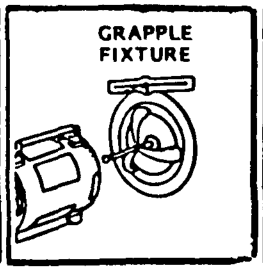
EVA SERVICING – MAINT HDWR

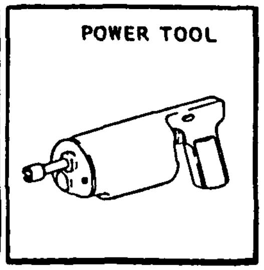
TYPICAL EVA AIDS IN WORK & EXISTING ASE

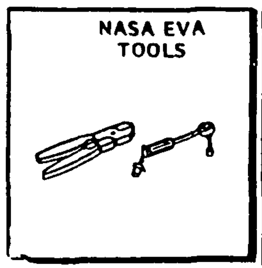
DVLOPMT NEED EVA AIDS*	FUND DSN (C/D)	FUND CNCT DSN	EXMPL & ALT SVC REF XMPL (EXMPL)	EXMPL & ALT SVC REF XMPL (ALT)
1. APPEND LTCH OVRD	●		◀	▶
2. GRAPL FIX-PORT	●		◀	▶
3. PWR WRENCH		●	◀	▶
4. RTCH-TQ WRENCH	●		◀	
5. OPN CHRY PCKER		●	◀	
6. UMB-AUTO/MAN	●		◀	
7. FLD XFER PNL		●	◀	
8.				

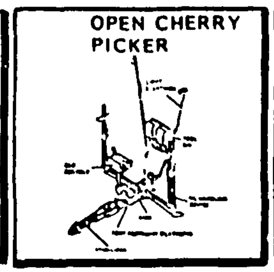
DEVELOPMT NEED ASE TO ENHNC EVA	NO NEW DEV REQD	ADDED DEV REQD
1. TILT/ROTATE TBLE*		●
2. RETENT MECHANSMS*		●
3. SPIN TABLE (?)	●	
4. PALLET*	◐	
5. PIDA		

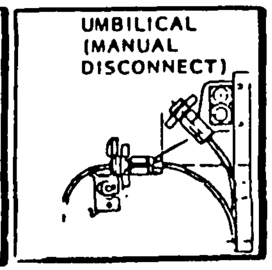












◐ = QUESTIONABLE NEW DEV NEED

* = STATION APPLICABLE

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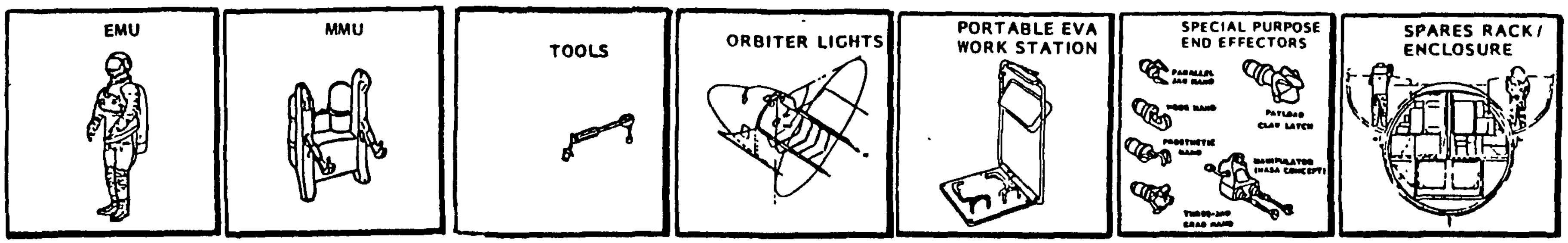
EVA SERVICING & MAINTENANCE HDWR – TYPICAL
EVA AIDS & ASE STUDIES/CONCEPT

DEVELOPMT NEED EVA AIDS*	STUDY CONTRACT	CNCPT ONLY	ADV SVC REF EXAMPLE
1. EMU MODS & 'AD-ONS'	●		
2. MMU MODS & 'AD-ONS'	●		◀
3. 'SLECTD' NEW HND TLS		●	◀
4. SUN SHIELD		●	
5. LIGHTING ENHNCEMT		●	◀
6. UNIV WORK STAND		●	◀
7. CONSTR/ASSY TLS/DEV		●	◀
8. RADIATION SHIELD		●	◀

ADV SVC REF EXAMPLE	DEVELOPMT NEED ASE TO ENH EVA*	STUDY CONTRACT	CNCPT ONLY
▶	1. FLUID TRNSR SYS	●	
	2. S/C HLD ASSY	●	
▶	3. DXTRS END EFCTRS	◐	
▶	4. ADV WK STA/SP PAL		●
	5.		



◐ = QUESTIONABLE AS TO ACTUAL STUDY CONTRACT * = STATION APPLICABLE

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S/C ORBITAL REPLACEMENT UNIT (ORU) UPDATE

A. S/C CAN BE DESIGNED TO ACCOMMODATE CHANGEOUT OF 'OLD OR OUTDATED' ORUs TO PERMIT INSTALLATION OF NEW/UPRATED/UPGRATED ORUs

B. FREQUENTLY THERE IS ACTUALLY LITTLE IMPACT FOR 'ORU UPDATE' IF THE CAPABILITY HAS BEEN DESIGNED INTO THE S/C

C. TYPICAL DESIGNED-IN TECHNIQUES INCLUDE:

1. USE OF CONNECTORS WITH SEVERAL MORE PINS THAN REQUIRED
2. USE OF STANDARDIZED MOUNTING & INTERFACE FEATURES:
   - RAILS/GUIDES
   - I/F ALIGNMENT REGISTRY
   - MOUNTING FASTENERS
   - MODULE/SUB-MODULE CONFIG
   - STRUCTURAL LOAD POINT DESIGN
   - THERMAL SURFACE INTERFACES
   - INDEXING/ORIENTATION
   - INSTALLATION VOLUME
   - CONNECTOR I/F POINTS
   - CONSUMABLE RESUPPLY I/F POINTS
   - TEST-C/O INTERFACE POINTS
   - GROUND HANDLING INTERFACES
   - GROUNDING TECHNIQUES
3. DATA SYSTEM INTERACTION STANDARDIZATION:
   - COMPUTER (BYTES & BITS)
   - INSTRUMENTATION & C/O
   - DATA STORAGE
   - DATA DUMP
   - DATA COMPRESION
   - DATA HANDLING/ROUTING
4. THERMAL DISSIPATION AND PROTECTION
   - ACTIVE
   - PASSIVE

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S/C ORBITAL REPLACEMENT UNIT (ORU) UPDATE (CONTINUED)

5. S/C WIRING STANDARDIZATION:
   - QUANTITIES/TYPES
   - INTERFACES
     - POWER - INSTR - GRND C/O I/F - CONNECTORS (TYPE & AVAIL PINS)
     - DMS - RECORDERS - AFT FLT DECK I/F
   - PROTECTION
     - DAMAGE - EMI - THERMAL
6. POWER PROVISIONS STANDARDIZATION:
   - TYPE
   - CONDITIONING/REGULATION
   - PEAK VS AVERAGE VS SURVIVAL
7. LAUNCH ENVIRONMENT STANDARDIZATION
   - CONTAMINATION PROTECTION
   - HEAT-SURVIVABLE & MIN OPS LEVEL
   - LOADS & VIBRATION PROTECTION
8. AIRBORN SUPPORT EQUIPMENT I/F STANDARDIZATION
   - MOUNTING & 'PICK-UP' POINTS
   - EVA AIDS - I/Fs & LOCATIONS
   - RAIL ENGAGEMENT
   - CONNECTOR I/Fs & COVERS
   - CODING/MARKING
9. OPTICAL BENCH STANDARDIZATION:
   - ALIGNMENT
   - PACKAGING FOR ON-ORBIT IVA SERVICE

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REDUCED ORU IMPLEMENTATION COSTS NOW REALIZABLE

A. REPRESENTATIVE COMPLIMENT OF ORU PACKAGING AND INTERFACE DESIGNS NOW AVAILABLE FOR TYPICAL S/C

B. CONNECTOR TYPES (VARIETIES, SHELL SIZES, PIN COUNTS AND WING TABS) NOW AVAILABLE AS STANDARD HARDWARE FROM VENDOR

C. HOLD-DOWN FASTENERS IDENTIFIED AND NOW STANDARD VENDOR HARDWARE

D. THERMAL (COLD PLATE) SURFACE DEFINED AND THRU THERMAL TEST-CONSEQUENTLY AN APPROACH HAS BEEN DEVELOPED

E. SHARP CORNER/EDGE/RADIUS ISSUE IDENTIFIED/RESOLVED
- DIMENSIONS AGREED UPON
- EDGE/CORNER APPLICATION KIT DEFINED AND THRU MATERIAL STANDARDS

F. TOOLING HARDWARE DEVELOPMENT ISSUE RECENTLY RESOLVED VIA P-380 PROGRAM
- MAJOR COST REDUCTION

G. CREW AIDS (TETHERS AND HANDHOLDS) DEFINED AND THRU DESIGN (PRE-FLT HDWR FAB)

H. CONNECTOR MATE/DEMATE (AND ASSOCIATED ORU TRAYS) APPROACH SOLVED, MOCKUPS FABRICATED AND TESTS COMPLETED TO PROVE CONCEPT
- DRIVE FASTENERS DEFINED AND NOW STANDARD PART

'NEW' EVA TASKS ENVISIONED FOR ADV SHUTTLE SUPPORT

EXTENSIVE GLOVE-TOOL/AID I/F (REPAIR-MAINTENANCE)

- SPLICE
- SEAL
- STRAIGHTEN
- TRIM/SMOOTH
- DRILL HOLE
- 'SAW'
- WELD
- STRIKE/PUNCH
- REAM
- FASTEN
- CUT
- BRUSH
- SOLDER
- BEND
- SHAPE
- SCRAPE
- FUSE BOND
- RIVET
- ETC

SIMPLIFIED GLOVE-TOOL OR UNIT I/F (SERVICE)

- RETRIEVE
- ADHERE
- CALIBRATE
- INITIATE SELF-CHK
- ISOLATE/DIVERT
- TROUBLE SHOOT
- LUBRICATE
- GAGE/MEASURE
- CLAMP
- HANDLE CABLE
- STABILIZE
- DECONTAMINATE
- CLEAN SURFACE
- VENT/PURGE
- START/SHUT-DWN
- PERFORM ALIGNMT
- PLACE LABELS
- CLEAN-UP AREA
- OPERATE D&C PANEL
- ETC

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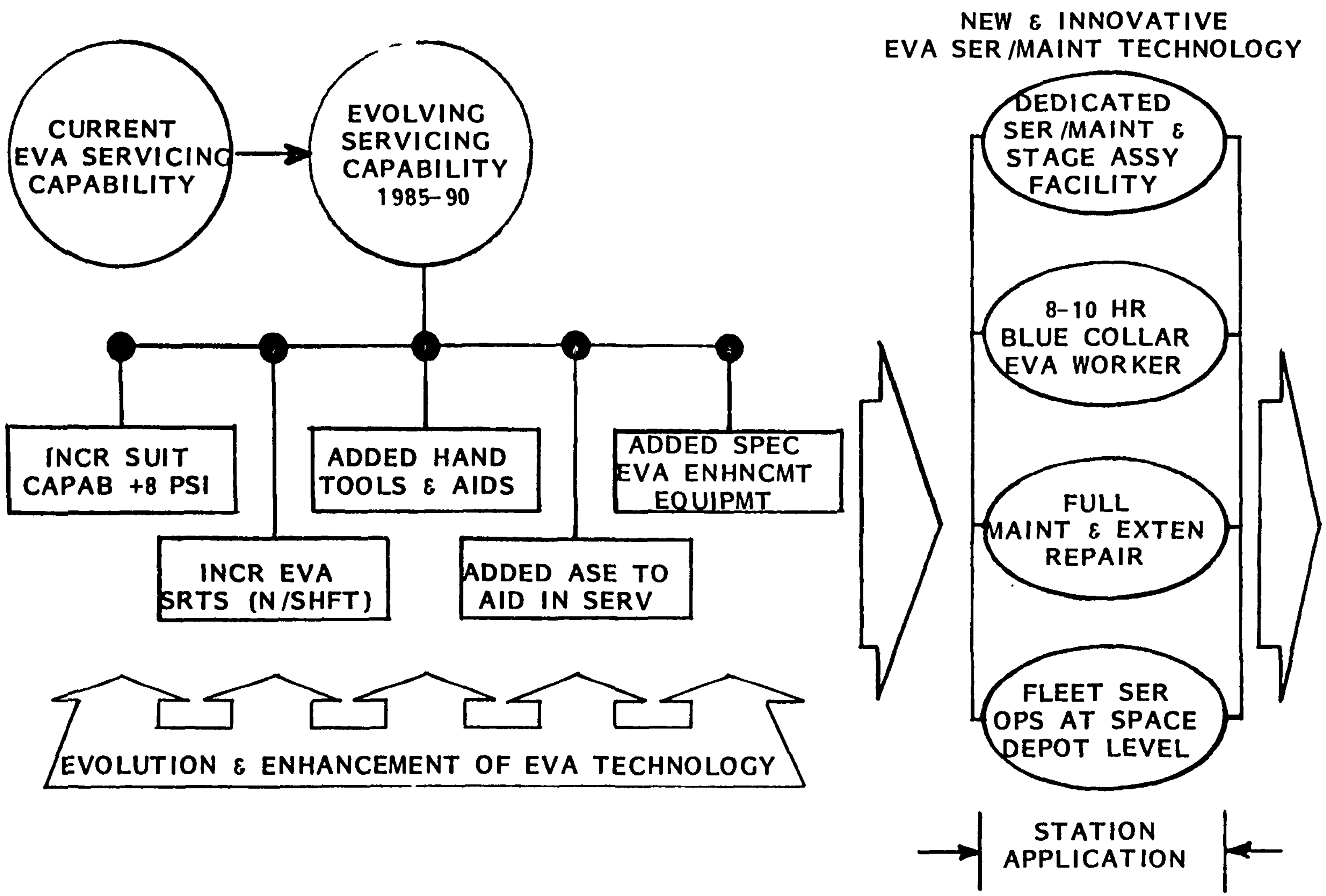
EVA TECHNOLOGY EVOLUTION - SHUTTLE TO STATION



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EVA TECHNOLOGY DEVELOPMENT NEEDS

1. DEVELOPMENT OF AN EVA POLICY

2. ENHANCED & ADDED EVA AIDS
   - MORE VERSATILE/EASIER TO USE FT REST
   - STANDARD TETHER RINGS (EQUIP/PERS)
   - STANDARD XLATION RAILS & STAND-OFFS
   - STANDARDIZATION OF TOOLS
   - SELECTED INCREASE RANGE OF TLS/AIDS
   - STANDARD-UNIVERSAL LIGHT
   - ENHANCED TOOL/AID STOWAGE/HOLDING
   - ENHANCED TETHERING TECHNIQUES
   - GREATER BUILT-IN SAFETY FEATURES
   - ETC

3. READIATION PROTECTION
   - DEFINITIVE RAD GUIDE/REQT
   - PROTECTION TECH INVESTIGATN
     - CREW WORN VS 'SHELTER' VS TEMP
   - ETC

4. CREW RESCUE (TYPICAL):
   - EMU ADJUNCTS
   - CAPSULES/BUBBLES
   - LIFE BOATS/SHELTERS/RETREATS
   - RESCUE VEHICLE
   - EMER MEDICAL SUPPORT SYSTEM
   - EMER EVA/IVA SURVIVAL KITS
   - ETC

5. EXTRA-VEHICULAR MOBILITY UNIT (EMU)
   - NON-VENTING HEAT SINK (CONCERN = 1.72 LB/HR OF H_2O)
   - INCREASED MONITORING & CONTROL CAPAB
   - VOICE CONTROL
   - NO PRE-BREATHE REQUIREMENT
   - EQUAL OR INCREASED JOINT 'MOBILITY' WITH INCR SUIT PRESSURE (e.g., 8 PSI)
   - GLOVES DESIGNED FOR RIGOR OF HVY WORK
   - RUGGED OVERGARMENT FOR:
     - RADIATION PROTECTION
     - THERMAL INSULATION
     - PUNCTURE/TEARING/ABRASION PROTECT
   - HELMET ENHANCEMENTS
     - ADJUSTABLE VISORING
     - WIDER FIELD OF VISION THAN 185°
     - HEAD-UP DISPLAY
   - ENCLOSURE WRIST ADAPTOR FOR TOOLS (W/BREAKAWAY)
   - AUTOMATIC TEMPERATURE CONTROL
   - LSS POWER I/F FROM WORKSITE
   - PORTABLE TV MONITOR
   - RANGE-RATE-SPIN DETECTOR (RADAR OR LASER)
   - GLOVE MOUNTED (OPTIONAL) HAND SPOT LIGHT)

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CONCLUSIONS

A. THE BASIS FOR SERVICING FROM THE ORBITER HAS BEEN ESTABLISHED

B. CONSIDERABLE TECHNOLOGY AND ASSOCIATED APPROACHES EXIST FOR DESIGN OF SPACE-CRAFT FOR ON-ORBIT SERVICING/MAINTENANCE

C. DESIGN FOR ON-ORBIT SERVICING/MAINTENANCE IS GENERALLY NOT CONSIDERED EARLY ENOUGH IN THE PROGRAM IMPLEMENTATION CYCLE

D. PRIMARY CONCERN IN DESIGN FOR SERVICING/MAINTENANCE IS STANDARDIZATION

E. THE ISSUE OF 'SPARES' CONTINUES TO BE A PROGRAM LEVEL PROBLEM

F. ADEQUATE EVA SERVICING HDWR EXISTS FOR INITIAL CHANGEOUT SERVICING FUNCTIONS

G. NEW EVA SERVICING TECHNOLOGY DEVELOPMENT IS PROCEDING IN A FRAGMENTED MANNER:
   1. FRAGMENTATION PRIMARILY CREATED BY FUNDING RESTRICTIONS
   2. NASA MAKING EFFORTS TO FOCUS-IN ON THIS CONCERN
   3. NASA/DoD TECHNOLOGY DEVELOPMENT COMPATIBILITY NOT YET INTEGRATED

H. LITTLE EFFORT YET EXPENDED ON DEFINING AN EVA TECHNOLOGY EVOLUTION AND DEVELOPMENT PROGRAM FOR POTENTIAL TRANSITION TO THE STATION

I. IT IS NOT TOO EARLY TO BEGIN DEVELOPING AN ORBITAL SERVICING AND MAINTENANCE CONCEPT(S) FOR SPACE STATION

J. NO INTEGRATED SERVICING AND REL/MAINT APPROACH AND ASSOCIATED DOCUMENTATION EXISTS TO INITIATE SPACE STATION EARLY PLANNING/ANALYSIS

K. BOTH THE NASA AND CONTRACTORS CAN PLAY A PIVOTAL ROLE IN DEVELOPING AND IMPLEMENTING AN ORBITAL SERVICING REL/MAINT CONCEPT(S), DOCUMENTATION, AND THUS, A MORE INTEGRATED STATION IMPLEMENTATION APPROACH

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RECOMMENDATIONS

A. EVA TECHNOLOGY PRESENTED IN THE VARIOUS PAPERS AT THIS CONFERENCE SHOULD BE COMPILED AND ACTIVITY INITIATED:

1. CATEGORIES SHOULD BE ESTABLISHED
2. AGREEMENTS (AT LEAST TENTATIVE) SHOULD BE REACHED ON THE MAJORITY OF SUB-CATEGORY LISTS
3. SOME ACCORD OUGHT TO BE ACHIEVED IN DETERMINING CERTAIN PRIORITIES

B. THE PANEL AND 'COMMITTED MEMBERS' SHOULD CONTINUE AS A TEAM:

1. FURTHER IDENTIFY/DEFINE THE TECHNOLOGIES
2. PREPARE TECHNOLOGY STUDY/DEVELOPMENT SCHEDULES
3. DELINEATE COST FACTORS FOR THE TECHNOLOGIES AND PRIORITIZE
4. ESTABLISH AN EVOLUTION PLAN - SHUTTLE TO STATION ERA
5. ESTABLISH A MORE RIGOROUS LIAISON WITH DoD AND CONTINUE INTERFACE WITH THE AIAA/USAF MAN-IN-SPACE PANEL
6. PREPARE INTERIUM AND INFORMAL PANEL INPUTS

C. THE NASA PANEL SHOULD CONSIDER OBTAINING MODEST FUNDS FOR TECHNOLOGY PANEL EFFORTS:

1. ONE OF THE PROBLEMS CONFRONTING THE AIAA/USAF MAN-IN-SPACE TECHNOLOGY PANEL
2. CONTINUED FOLLOW-UP OF THIS PANEL IS HIGHLY IMPORTANT TO MORE NEAR-TERM SHUTTLE EVA TECHNOLOGY IMPLEMENTATION

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SPACE STATION PROGRAMS

ATTACHMENT 2

SUPPORTING DATA AND ANALYSIS REPORTS

VOLUME II

MANNED SYSTEM TECHNOLOGY REQUIREMENTS

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MANNED SYSTEM TECHNOLOGY REQTS

Presentation To

SPACE STATION TECHNOLOGY WORKSHOP

HUMAN CAPABILITIES PANEL

Dr. Alan Chambers , Chairman

28 MARCH 1983

H. T. Fisher

Crew Systems Supervisor

Lockheed Missiles & Space Company

PRESENTATION OBJECTIVES

A. TO PRESENT A VERY GENERAL OVERVIEW (POT·POUR·RI) OF SELECTED MANNED SYSTEM TECHNOLOGY STUDY/DEVELOPMENT NEEDS

B. TO PROMOTE AN OPEN, LIVELY, SLEEVES ROLLED-UP INTERACTIVE SESSION

C. TO AID IN TRANSMITTING TO THIS ASSEMBLED GROUP SELECTED RESULTS/RECOMMENDATIONS OF THE AIAA/USAF MAN-IN-SPACE TECHNOLOGY PANEL*

D. TO ASSIST IN GATHERING NASA/CONTRACTOR HUMAN CAPABILITIES TECHNOLOGY PANEL RESULTS FOR USE IN SUBSEQUENT AIAA/USAF MAN-IN-SPACE PANEL ACTIVITIES

E. TO ENCOURAGE MORE DIRECT & FREQUENT DIALOGUE BETWEEN THE NASA & USAF HUMAN/MANNED SYSTEM TECHNOLOGY PANELS

* GRACIOUS ACKNOWLEDGEMENT IS GIVEN TO THE AUTHORS OF THE AIAA/USAF MAN-IN-SPACE TECHNOLOGY PANEL (IN PARTICULAR, PAUL BUCHANAN, M.D.) FOR LIBERAL USE OF THEIR MATERIALS HEREIN

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PRESENTATION CONTENTS

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STATION OPERATIONS-COMMAND & MONITOR TECHNOLOGY (SELECTED FACTORS)

The facing and following page present, in a very simplified manner, areas of potential technology investigation and development relative to on-board man-in-the-loop command and monitor technology. These selected factors indicate only some of the top-tier factors to be considered when developing an integrated man-machine crew work station, e.g., interactive display and control station. As indicated, use of multiple microcomputers within the station is becoming a more viable concept and certainly worth further investigation. The issue of certralized vs decentralized capabilities is also integrally woven into the multiple microcomputer consideration matrix. Basic command and monitor system operations are most worthy of further consideration, particularly in light of the state-of-the-art effort being conducted by the military for 'battlefield' commanders and presently being installed in operational systems. Continued work in the area of displays and controls promotes a difficulty in literally keeping up with the state-of-the-art due to the extensiveness of research and the breadth of firms and countries now involved in this area. Security (e.g., the US National Security Mission associated with the station) continues to be a pivotal issue in information handling and processing, notwithstanding the need for communication. Finally, the dilemma of the use of the crew person and ageless question of his or her integration (level) and participation (extent) in the system continues to be a challenge for the crew systems analyst.

STATION OPERATIONS -
COMMAND & MONITOR TECHNOLOGY (SELECTED FACTORS)

A. 'TRADITIONAL' C&M SPACECRAFT/STATION APPROACHES ARE NOW RELATIVELY OBSOLESCENT

B. STATE-OF-ART & APPROACHES PROGRESSING RAPIDLY & MAJOR 'SHIFTS' IN APPROACHES EXPECTED

C. TYPICAL AREAS WHEREIN C&M TECHNOLOGY STUDY CAN ENHANCE CREW STATION & MISSION SUPPORT OPS:

1. USE OF MICRO-PROCESSORS & ALPHA-NUMERIC-SYMBOLOGY DISPLAYS:
   - 'MINI-FLEX' VS 'MAXI-FLEX' INTERROGATION & PATH FINDING
   - MENU UTILIZATION & LOGIC FLOW CONSTRUCTS
   - INFORMATION ENHANCEMENT - FORMAT/COLOR/SYMBOLOGY/CONSTRUCT
   - ALARM & EMERGENCY INFORMATION PRESENTATION, ISOLATION & ACTION RESPONSE
   - SITUATION, DIAGNOSIS & PROBLEM SOLVING LOGIC & PRESENTATION METHODS
   - INHERENT FLEXIBILITY-INFORMATION UPDATE, SOFTWARE HANDLING & VERSITILITY
   - USER FRIENDLY INTERACTION & PROMPTING/CUES
   - ETC
2. CENTRALIZED VS DECENTRALIZED CAPABILITIES:
   - MICRO-PROCESSORS
   - MAIN VS ALTERNATE VS BACK-UP CREW C&M WORK STATIONS & SUB-STATIONS
   - SYSTEM UPDATE & 'LINK CHINKS'
   - GRACEFULL DEGRADATION VS DROP-OFF-LINE VS TOTAL LOSS
   - HARDWIRE VS MICRO-PROCESSING
   - SYSTEM NET & NEURAL NETWORK INTERFACE

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STATION OPERATIONS -
COMMAND & MONITOR TECHNOLOGY (CONT'D)

3. C&M SUB-SYSTEM OPS
   - EASE OF SET-UP & INITIATION
   - INTERACTION LOOPS-GROUND, FREE FLYERS, ATTACHED ELEMENTS, ETC.
   - REFRESH, UPDATE & ON-LINE CHANGES
   - FLEXIBILITY/VERSITILITY VS 'USEABILITY'
   - LEVELS OF AUTONOMY & AUTOMATION VS HUMAN INTERACTION
   - WHEN & WHY TO GET THE HUMAN OUT-OF-THE-LOOP
   - ARTIFICIAL INTELLEGENCE VS INTELLIGENT SYSTEMS
   - HUMAN ERROR & SUB-SYSTEM OPERABILITY
   - HISTORICAL DATA, TRENDS & PREDICTIVE NEEDS
   - SELF-CHECK & 'CONFIDENCE' - DOES THE CREWPERSON BELIEVE IT
   - STIMULUS VS RESPONSE
   - C&M SUB-SYSTEM DEGREDATION - WHAT THEN(?)
   - ETC
4. BASIC C&M WORK STATION LAYOUT(S) AND NOS OF STATIONS & MINI-STATIONS
5. DISPLAY & CONTROL TECHNOLOGY EVOLUTION & TRENDS
   - VOICE CONTROL
   - TOUCH PANELS
   - DISPLAY DEVICES
   - REMOTE ITEM OPS
   - ETC
   - LIGHT PENS & OVERLAY/PROGRAMMABLE KEYBOARDS
   - REAL-TIME TRACKING
   - USER FRIENDLY 'TERMINALS'
   - ALARMS
6. SECURITY
7. THE DILEMMA! TOO MUCH - TOO COMPLEX - TOO SPECIALIZED?

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CONSIDERATIONS FOR ADVANCED WORK STATION TECHNOLOGY DEVELOPMENT

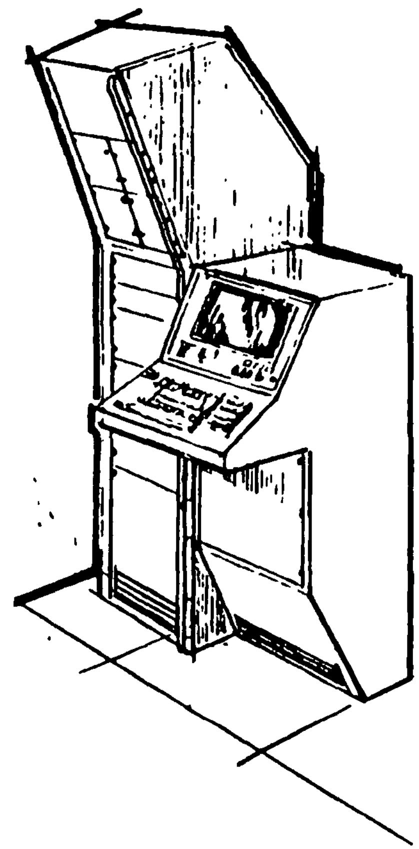
The current traditional spacecraft console/panel work station and the now out-moded (1972 technology) Orbiter flight deck system necessitates a new and fresh examination, particularly in light of the tremendous new advances in microprocessing and software. This effort will be a continuous one and will constantly be influenced by the ever-changing state-of-the-art in both computer and display device technology, as well as new and innovative use of the human in such areas as 'touch control' and voice input. A set of selected potential study, research, and development areas is presented on the facing page; however, the list is only typical and needs further expansion and greater clarification as to explicit content.

CONSIDERATIONS FOR ADV WORK STA TECHNOLOGY DEV

A. ADVANCED CREW WORK STATIONS-D&C
1. MAJOR ADVANCE TO NEW DISPLAY TECHNOLOGY
2. CONSOLE & GROUP DISPLAYS
3. KEYBOARD & FLAT PANEL DISPLAY ONLY CONCEPTS
4. TOUCH CONTROL } COMBINATIONS
5. VOICE CONTROL } COMBINATIONS
6. MULTI-JOYSTICK OPS
7. FULLY PROGRAMMABLE DISPLAYS
8. DROP-IN CASSETTE UNITS FOR REPROGRAMMING
9. NEW PERSPECTIVE DISPLAYS VS TYP 2 DIMENSIONS
10. ADVANCED MENUE PATH FINDING & LOGIC

B. ADVANCED CREW WORK STATIONS
1. PROJECT 8-12 YEAR CONCEPT FORECAST
2. ADVANCED MODULARITY WITH CROSS REDUNDANCY
3. MULTI-LOCATION POSITIONABLE
4. MULTI-SUBSYSTEM APPLICABILITY
5. SIMPLIFIED SPARES APPROACH
6. MODULAR BUILD-UP FLEXIBILITY VS DEDICATED UNITS

C. ADVANCED CREW WORK STATIONS - OPS
1. DESIGN FOR MIN TRNG TO FUNCTIONALLY OPERATE
2. USER FRIENDLY & RAPID RESPONSE CAPABILITY
3. MULTI-POSITION MAINT ACCESS
4. PROVIDE INHERENT TRNG OPERATIONS S/W CASSETTE
5. DETERMINE NATURE OF ART INTELL VS INTELL SYS



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The opposite page presents a simplified breakdown of the habitat sub-elements, and although not intended to be inclusive, indicates in general, many of the areas/elements of the living habitat. Adjacent to the breakdown is a list of candidate study, research, and development factors worthy of discussion relative to future commitment for technology development effort. These factors need further expansion and prioritization before embarking upon a technology development effort. Care should be exercised in assuring that the results of previous flights (e.g., Skylab) and future missions (e.g., Spacelab) are taken into account and lessons learned carefully examined and reviewed so as to establish proper lines of research and study and, as importantly, assigning appropriate priorities.

CREW STATION DESIGN - LIVING HABITAT

HABITAT SUB-ELEMENTS

- COMPARTMENTS/SUB-COMPARTMENTS
- AIRLOCK(S)
- TUNNEL(S) & HATCHES
- SLEEP QUARTERS & PRIVACY
- HYGIENE STATIONS
  - √ TOILET
  - √ LAVATORY
- GARMENT/CLOTH CARE SUB-STA (LNDRY)
- GALLEY
  - √ FOOD PREP
  - √ SCULLERY & WASTE DISPOSAL
  - √ REFRIGERATION/FREEZING
  - √ EATING ZONES
- STOWAGE COMPARTMENTS
- OPEN AREAS
  - √ TRANSLATION
  - √ EXERCISE
  - √ REST/RECREATION
- HABITAT CONTROL SUB-STATION
- ILLUMINATION SUB-SYSTEM
- ECLSS

↓
ETC

TYPICAL STUDY FACTORS

- CREW QUANTITIES
- CREW MIX-INCLUDING FEMALES
- CREW COMPARTMT UTILIZATION
- DIVISION/FREQUENCY OF HOUSEKP TSKS
- MOTION DYNAMICS IMPACT
- ENVIRONMT-TEMP/HUMID/GAS COMP/ACCOU
- EXTERNAL VIEWING (VWPTS/WND,CCTV,ETC)
- HABIT VOL: AVAIL CU FT PER CREWPSN
- PRIVACY & ISOLATION
- SMELL & ODOR
- COMFORT FACTORS
- TRANS AIDS/RESTR & TRAFFIC PATTERNS
- INTERIOR MATERIALS-COLOR/SHP/TEXTURE
- INTERNAL RE-CONFIGURABILITY
- GROUP BEHAVIOR/DYNAMICS
- GARMENTS-TYPE/STYLE/TEXTURE/COLOR
- ILLUMINATION-LOCATION/LEVEL/TYPE
- RECREATION & HOBBIES
- PERSONAL ITEM NEEDS & STOWAGE/ACCESS
- 'FURNITURE' & ACCOMMODATIONS
- LOGISTICS/WASTE HANDLING
- LAYOUT ARRANGEMTS & ORIENTATION
- ANTHROPOMETRICS

↓
ETC

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CREW SUPPORT TECHNOLOGY DEVELOPMENT NEEDS

The facing page lists two areas wherein further technology research and development appear warranted; food systems and personal item support needs. A suggested set of candidate factors for potential study have been listed, and it is assumed that the two lists will be expanded and synthesized to assure appropriate consideration of the necessary items. To date, food systems technology has been advancing at a relatively reasonable rate; however, based on the high cost of launch to orbit weight constraints, often severe limitations have been placed on the development of a truely 'palatable' and flexible food system. With the requirement to support multiple crew members for extended periods of time (90 days or more), this area appears 'ripe' for 'fruitful' investigation. Similarly, attention to personal needs and support requirements will take on an ever-increasing importance -- particularly when coupled with the food/meal factors as they relate to morale and psychological status of the crew person during orbital stays.

CREW SUPPORT TECHNOLOGY DEVELOPMENT NEEDS

FOOD SYSTEMS TECHNOLOGY NEEDS

1. FOOD PRESERVATION
2. FOOD PACKAGING
   - COMPRESSION
   - ESTHETICS
   - CONTAINERS
   - STOWABILITY
3. PALATABILITY
   - TEXTURE/FLAVOR/COLOR/SMELL
4. FOOD PREPARATION TECHNIQUES
5. RECONSTITUTION
6. HEATING & CHILLING
7. WATER - HOT & COLD
8. INDIVIDUAL SELECTION & CONDIMENTS
9. VARIETY & INHERENT MENUE
10. FOOD SUBSTITUTES & CHEMICAL FOOD SYN
11. CLOSED ECLSS & ON-BOARD FOOD GROWTH
12. NUTRITIONAL BALANCE VS CALORIC INTAKE
13. FOOD PREPARATION EFFICIENCY
14. EMERGENCY FOOD SUPPLY
15. FOOD STOWAGE & PREPARATION TECHNIQUES
   - LOCKERS
   - OVEN(S)
   - SERVING
   - REFRIG
   - FREEZER
   - ETC
16. WASTE HANDLING & SCULLERY

PERSONAL ITEM &/OR SUPPORT TECH NEEDS

1. SLEEP COMPARTMENT (TYPICAL):
   - COMM
   - CCTV
   - IND CASETTES
   - ADJ LITE
   - FAN
   - VIEW PORT
   - GARMT STOW
   - HYG KIT
   - WRITING SURFACE
   - GEN UTILITY STOWAGE
   - PRIVACY PARTN
2. RECREATION (TYPICAL):
   - HOBBY KITS
   - GAMES
   - PHOTO/ART
   - EXERCISE
   - VDO TPS
   - RECORDERS
3. CREW IVA AIDS (TYPICAL):
   - HANDHOLDS
   - HANDRLS
   - XLATION RAILS
   - PLUG-IN LITE
   - GN TOOL
   - 'STICK PATCHES'
   - WASTE 'DMP'
   - RCORDS
   - DATA/INFO PKTS
   - VAC CL
   - PWR CDS
   - TIMERS
4. GARMENTS
   - NEW/STD SHIRTSLEEVE CLOTHING & SIZING
   - DISPOSABLE VS WASHABLE CLOTHING
   - ODOR CONTROL & HYGIENIC HANDLING
   - FOOTWARE (NOMINAL & ZERO-G [?]
   - COLOR/TEXTURE/STYLE - MALE/FEMALE

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The facing page presents two separate technology areas. The first, operator function technology, attempts to address the area of examining how the operator fits into the environment and work situation, and accordingly, how best to use him or her; and secondly, how to 'manipulate' and design the environment to enhance operator utilization. The list of functional enhancement only addresses a few of the issues and, therefore, needs further amplification. The major area of servicing and maintenance spreads across several functional zones of the station operational infra-structure. Accordingly, this area has extensive and broad ranging implications and definite cross relationships. Both internal and external servicing and maintenance of the station must be considered simultaneously, and particularly as an element of the overall space integrated logistics system. Also, servicing and maintenance of the mission elements, e.g., attached payloads, free flyers, tethered items, etc., additionally necessitate major investigation. Each of these afore-mentioned areas has extensive impact on the architectural development of the station, and as such, require early and careful consideration if the crew is to be successfully integrated into these operational elements and the station system architecture.

OPERATOR FUNCTION & SERVICING TECHNOLOGY STUDY/DEVELOPMENT NEEDS

OPERATOR FUNCTION TECHNOLOGY

1. OPERATIONAL (IVA) FUNCT I/F ENHANCEMT
   - CREW TASK OVERLOADING-HOW TO DETERMINE
   - NON-FULL USE OF CREW 'MENTAL' CAPABILITIES
   - NOS OF & CROSS INTERACTION OF CREW
   - CREW DEGRADATN/RELIABILTY OVER TIME/LOAD
   - INFO-REQD VS DECISION
   - CREW ACCEPT OF 'NEW' D&C TECHNOLOGY
   - INFO/DATA FORMAT/CONTENT VS CREW INTERPRE
   - PERCEPTION & COGNITIVE CAPABILITIES
   - INFMATN BANDWITH/SOURCES VS CREW SENSORS
   - SENSORY OVERLOAD
   - CUE CONTROL VS CREW RESPONSE
   - MULTIPLE TASK INTERACTION
   - TASK STRUCTURE
   - ETC
2. ENVIRONMENTAL FACTORS
   - TEMPERATURE/HUMIDITY
   - ILLUMINATION (LOCA, BRTNESS, COLOR & TYPE)
   - ATMOSPHERIC COMPOSITION
   - ACOUSTIC INVESTIGATN: MASK-BACKGRND
   - NOISE CONTROL
   - RADIATION MONITORING & CONTROL
   - COLOR/SHAPE/TEXTURE

SERVICING & MAINTENANCE

1. INTERNAL STATION SVC/MAINT
   - LEVELS
   - DIAG & CREW I/F
   - CMPTR UTIL
   - AUTONOMY VS GRND
   - CREW ACCESS
   - CREW SKILLS/TRNG
2. INTERNAL STA 'WORK-BNCH' MAINT
   - DEMO-INITIAL
   - CONTINGENCY
   - FEAS STUDIES
   - CAPABILITY EVOL
3. EXTERNAL STA SERVC/MAINT
   - EVA CAP
   - EQUIP/HDWR CATEGOR
   - STA IMPACT
   - CREW SKILLS/TRNG
   - SUPT EQUIP
   - SAFETY/HAZARDS
4. MISSION HDWR & P/L SERVC/MAINTENANCE
   - ACCESS (IV & EV)
   - LEVELS/TYPES
   - LOGISTICS
   - CREW C/O & DIAG
   - GRND-FLT CR I/F
   - CREW SKILL/TRNG
   - AUTONOMY VS GRND
   - SAFETY & HAZ
   - CREW VS AUTOMATN
   - CREW AIDS
   - TIMELINES
   - FEASIBILITY

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EVA TECHNOLOGY DEVELOPMENT NEEDS

This particular subject is being principally covered by another panel here at this conference. Nonetheless, the subject is worthy of mentioning to this group due to the inextricable interrelationship of many of these elements with the basic role of this panel. The importance of developing a clear and in-depth policy on EVA is critically needed and, quite frankly, has not been provided, although each EVA potential has been carefully examined and evaluated on a case-by-case basis. Standard approaches and clear direction has, however, often been lacking at the inception of a program and frequently doesn't exist until PDR or beyond! Other factors shown on the opposite page are indicative of areas for further study, research and actual hardware technology development. Again, as previously indicated, these factors must be carefully identified, defined, and prioritized prior to commitment of funds.

EVA TECHNOLOGY DEVELOPMENT NEEDS

1. DEVELOPMENT OF AN EVA POLICY

2. ENHANCED & ADDED EVA AIDS
   - MORE VERSATILE/EASIER TO USE FT REST
   - STANDARD TETHER RINGS (EQUIP/PERS)
   - STANDARD XLATION RAILS & STAND-OFFS
   - STANDARDIZATION OF TOOLS
   - SELECTED INCREASE RANGE OF TLS/AIDS
   - STANDARD-UNIVERSAL LIGHT
   - ENHANCED TOOL/AID STOWAGE/HOLDING
   - ENHANCED TETHERING TECHNIQUES
   - GREATER BUILT-IN SAFETY FEATURES
   - ETC

3. READIATION PROTECTION
   - DEFINITIVE RAD GUIDE/REQT
   - PROTECTION TECH INVESTIGATN
     - CREW WORN VS 'SHELTER' VS TEMP
   - ETC

4. CREW RESCUE (TYPICAL):
   - EMU ADJUNCTS
   - CAPSULES/BUBBLES
   - LIFE BOATS/SHELTERS/RETREATS
   - RESCUE VEHICLE
   - EMER MEDICAL SUPPORT SYSTEM
   - EMER EVA/IVA SURVIVAL KITS
   - ETC

5. EXTRA-VEHICULAR MOBILITY UNIT (EMU)
   - NON-VENTING HEAT SINK
     (CONCERN = 1.72 LB/HR OF H_2O)
   - INCREASED MONITORING & CONTROL CAPAB
   - VOICE CONTROL
   - NO PRE-BREATHE REQUIREMENT
   - EQUAL OR INCREASED JOINT 'MOBILITY' W/ WITH INCR SUIT PRESSURE (e.g., 8 PSI)
   - GLOVES DESIGNED FOR RIGOR OF HVY WORK
   - RUGGED OVERGARMENT FOR:
     - RADIATION PROTECTION
     - THERMAL INSULATION
     - PUNCTURE/TEARING/ABRASION PROTECT
   - HELMET ENHANCEMENTS
     - ADJUSTABLE VISORING
     - WIDER FIELD OF VISION THAN 185°
     - HEAD-UP DISPLAY
   - ENCLOSURE WRIST ADAPTOR FOR TOOLS (W/BREAKAWAY)
   - AUTOMATIC TEMPERATURE CONTROL
   - LSS POWER I/F FROM WORKSITE
   - PORTABLE TV MONITOR
   - RANGE-RATE-SPIN DETECTOR (RADAR OR LASER)
   - GLOVE MOUNTED (OPTIONAL) HAND SPOT LIGHT)

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This area is relatively new as to incorporation of the crew into the station effort; however, many elements will make up the total station infra-structure, and transportation spacecraft are integral to this program. Accordingly, a few simple factors have been presented as they might relate to crew integration into the transportation spacecraft element. The spacecraft presented in the facing page (far right) are a mixed bag of potential vehicles, some manned and others remotely controlled. Nevertheless, man is in-the-loop for all candidate spacecraft. The listing of potential spacecraft is rather speculative at this time; however, some type of orbital transport vehicle will be required to ferry spacecraft to and from the station -- particularly for servicing of free-flying spacecraft. This entire area is fully open to exciting new work for the crew systems contingent and, thus, warrants considerable attention in the future. However, funding for this area may not be immediate. Thus, any selection of further work must be carefully considered relative to its applicability and early visibility.

MANNED SYSTEMS TECHNOLOGY & ORBITAL TRANSPORT SYSTEMS

A. REMOTE CONTROL
(SEE ROBOTIC/TELEOP TECH NEEDS)

B. EMU I/F FEASIBILITY/PRACTICALITY

C. CONTINGENCY/EMER EVA SUPPORT

D. COMMUNICATIONS ENHANCEMENT

E. EMU TIMELINE ENHANCEMENT

F. EVA CREW USE EFFICIENCY

G. ADVANCED DISPLAY/CONTROL TECH

H. CREW SAFETY/PROTECT ENHANCEMT

I. CREW MAN-MACHINE DESIGN INTEG

J. ADV MAN-IN-LOOP OPS/FEEDBACK

K. ETC

TRANSPORT &/OR WORK AIDS

1. OTV WITH REMOTE 'SERVICER' & OPTION
   - AEROBRAKING
   - AERO-MANEUVERING
   - WITHOUT SERVICER
2. MANNED XPORT VEHICLE & OPTION
   - WITH OR WITHOUT 'SERVICER'
3. PROXIMITY OPS UNIT
4. SPACE PLANE
5. TELEOP MANEUVERING SYSTEM
6. INTRA-ORBIT TUG/'SCOOTER'
7. CREW RESCUE/UTILITY VEHICLE

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ROBOTICS/TELEOPERATIONS - TECHNOLOGY DEVELOPMENT CANDIDATES

Ths facing page simply lists a composite of parts (human and equipment) of potential robotic and/or teleoperator systems, and the basic issues associated with the six pre-defined elements. This list was prepared for another similar technology effort and has been reproduced exactly as presented. Further delineation of this list is necessary, and the effort put into the overall context of the robotic and/or teleoperator program. Certainly, the issues identified need to be prioritized and examined relative to importance, pacing needs, long-term procurements, etc., and integrated into the overall plans for the technology development efforts currently underway in this area.

ROBOTICS/TELEOPERATIONS - TECHNOLOGY DEVELOPMENT CANDIDATES

OPERATOR

PARTS
- Eyes, ears, hands, etc

ISSUES
- Operator acceptance of technology
- Number of operators required
- Single operator's time-constrained
- Capabilities
- Human endurance
- System response time
- Perceptual limits
- Information assimilation rate and capacity
- Cognitive limits

CONTROL STATION

PARTS
- Sensory display
- Command Generation

ISSUES
- Delay
- Control Station Architecture
- Method of stereo vision display
- Visual enhancement (e.g., false color, scene interpretation)
- Display mechanisms
- Command mechanisms
- Integration of display and command mechanisms
- Communication of task semantics

PROCESSING

PARTS
- Task-referenced control
- Detector data integration and interpretation for control
- Discrete decision making
- Estimation and recognition
- Sequencing of operations (serial & parallel)
- Coordination of multiple manipulators & processes
- Plan generation
- Error recovery

PROCESSING (CONTINUED)

ISSUES
- Degree of autonomy
- Servo loop stability
- Delay
- Information bandwidth
- Coordination of multiple effectors
- Collision avoidance
- Topography estimation
- Robust control
- "Mistake" monitoring

WORK SITE

PARTS
- Detectors
  - internal state
  - external state: contact/non-contact
- Effectors
- Actuators
- Linkages

ISSUES
- Lighting
- Detector configuration
- Space qualification
- Auto-focus and auto-point
- Number and configuration of effectors
- Design of effectors (combination of manipulators and detectors)
- Control of limber manipulators
- Scaling

TASK

PARTS
- Task-dependent

ISSUES
- Degree of structure
- Primitive operations
- Task board definition
- Experimental verification

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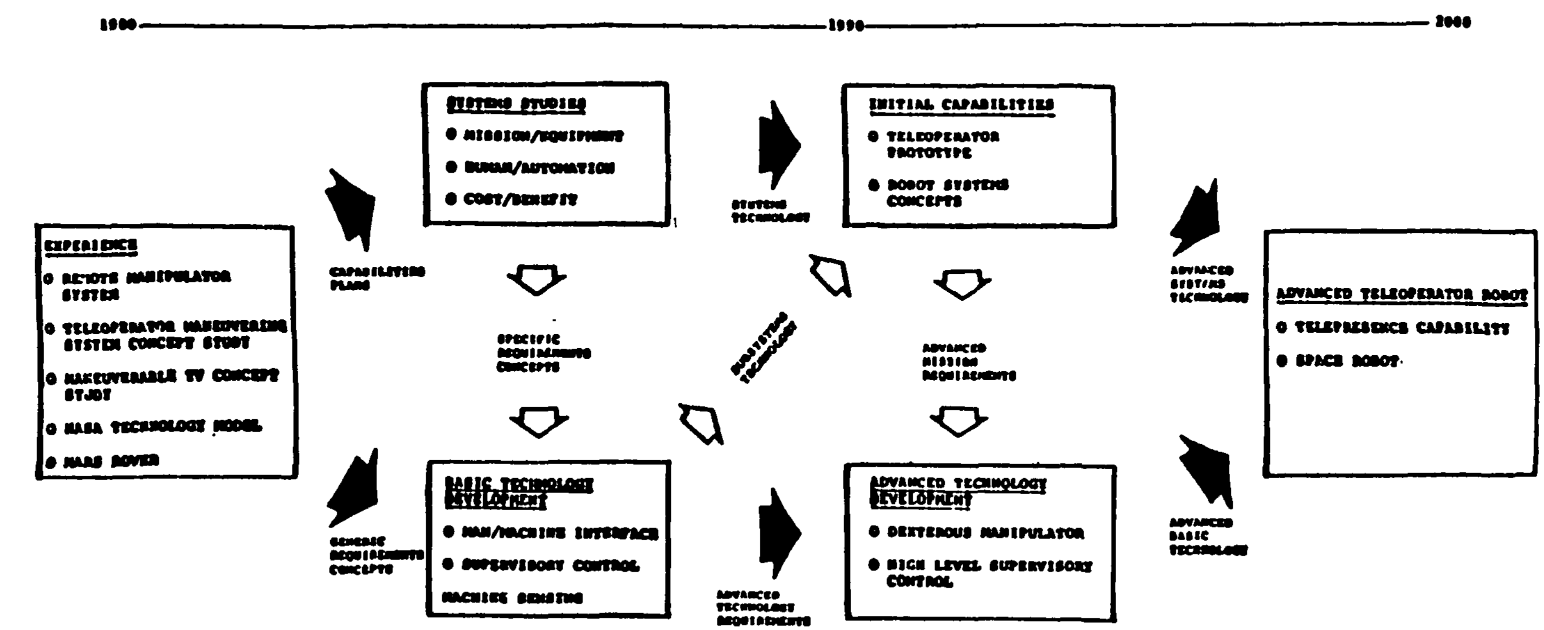
POSTULATED ROBOTICS/TELEOPERATOR TECHNOLOGY DEVELOPMENT PHASING

A simplified schedule flow of the technology development effort associated with the robotic and/or teleoperator elements is presented on the facing page. As with the previous page, this material was lifted from previous technology identification materials, and is presented here for discussion purposes and as a point for departure for subsequent review. It will be important to understand those studies and programs already underway in order to develop a meaningful technology development plan that meets previously stated objectives which, in themselves, may still need further definition and delineation as they relate to station operational needs.

POSTULATED ROBOTICS/TELEOPERATOR TECHNOLOGY DEVELOPMENT PHASING



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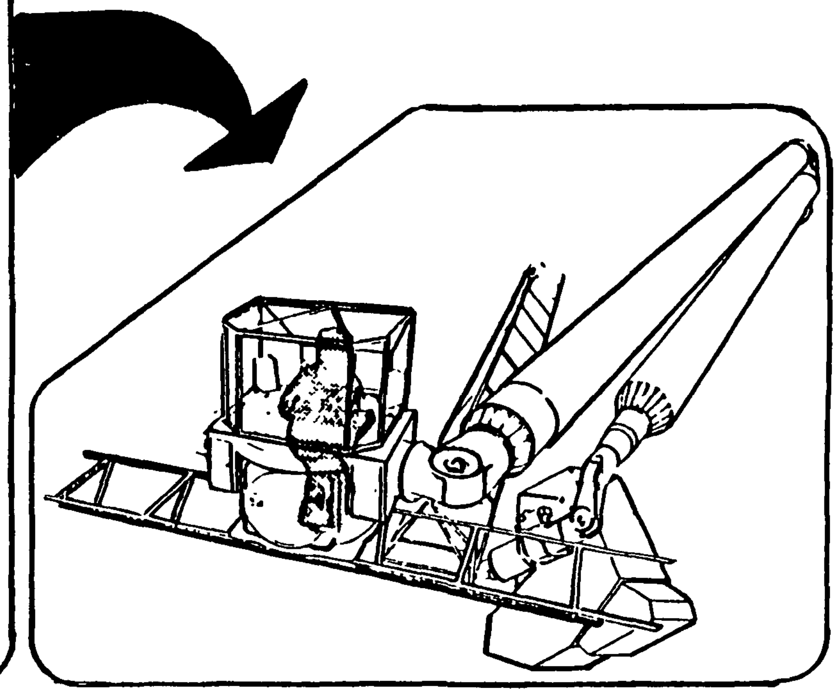
RMS/CRANE TECHNOLOGY STUDY/DEVELOPMENT CANDIDATES

The facing page lists a composite of selected areas of further study and research relative to the potential utilization of the RMS (as currently defined) and a future development effort candidate -- a crane concept. The list is not intended to be exhaustive, but rather included to stimulate further discussion. Spar of Canada has been working this area as part of the Space Station Definition study effort and, as such, has given a fair amount of thought to this subject. Little information appears available relative to detailed definition of a crane, although this idea has been discussed for several years. This effort may or may not be considered in concert with the previous area of robotics and/or teleoperators due to certain obvious similarities.

RMS CRANE TECHNOLOGY STUDY/DEV CANDIDATES

RMS/CRANE TECHNOLOGY DEV

1. DUAL-SIMULTANEOUS USE
2. UNITS ON TRACKS
   - POWER/SIGNAL I/F
   - MOBILITY/DYNAM
   - STA IMPACT
   - SIZE/MASS HANDLING
   - SWEPT VOL USE
   - DAMAGE ASSMT
3. OPEN VS CLOSED CABS & MAN-RATING
4. IVA (INTERNAL STA) VS 'AT' RMS (IVA OR EVA) OPS
5. SYSTEM PROCESSING
6. CONTROL STATION CAPABILITY
7. WORK END/SITE FEATURES
8. OPERATOR NEEDS
9. UNIT SUPPORT AIDS/EQUIPMT
10. MALFUNCTION DETECTION & INTERVENTION
11. EMERGENCY OPS
12. STEREOSCOPIC VISUAL AIDS
13. CREW VISIBILITY AIDS/PROTECTION
14. POSITIONING ACCURACY
15. COLATERAL DAMAGE POTENTIAL
16. UNIT LENGTHS (ARM/CRANE SEGMENTS)
17. UNIT ARTICULATION (JOINT RANGES/ANGLES)
18. BACK-UP CAPABILITY
19. DEVELOPMENT/FEASIBILITY UNITS & SIMULATORS
20. ETC



AFTER SPAR OF CANADA

HEALTH MAINTENANCE & MEDICAL CARE

This area is most significant, based both on criticality to life in space and also on the vast amount of effort associated with past, on-going, and future planned activities. The philosophy of the need for health care and medical needs is well handled in other documentation developed by the NASA. The intent of the facing page is simply to indicate the need for patient handling and the medical care categories anticipated during orbital operations. As the definition of the station matures, so, too will the health and medical care concepts, approaches, and hardware implementation. The categories presented on the far right of the opposite chart are included only for discussionary purposes and, undoubtedly, will be massaged as this area becomes more definitized.

HEALTH MAINTENENCE & MEDICAL CARE

PATIENT TRIAGE & HANDLING*

1. ILLNESS/INJURY TREATED & CREW PERSON RETURNED TO DUTY
2. 1ST CARE GIVEN ON-ORBIT (DAYS) & CREW PERSON RETURNED TO EARTH
3. EXTENSIVE TREATMENT FOR CONDITIONS WHERE EARTH RETURN NOT MEDICALLY ADVISABLE DUE TO XFER/RE-ENTRY/LANDING TRAUMA
4. RETURN TO EARTH IF DEATH OCCURS

MEDICAL CARE**

1. USUAL MEDICAL-SURG CONDITIONS OF ADULTS
   - NONWORK RELATED-MEDICAL OCCURRENCE
     e.g., INFECTION, HEART ATT, RENAL STONE
   - WORK RELATED-ACCIDENTS AND EXPOSURES
     e.g., FRAC, PUNCT WOUNDS, BRUIS, TX COMPDS
2. UNIQUE TO SPACE OCCUPATION
   - IN MICROGRAVITY
     e.g., SPACE SICKNESS, SINUSITIS, ESOPHAGITIS
   - RETURN FROM MICROGRAVITY
     e.g., MICROFRACT, JOINT INJ, POSTURAL HYPOXTSN
   - MICROGRAVITY ENV EFFECT ON PHARMACOKINETICS, NORMAL RANGES OF MEDICAL TESTING, RECOGNIZING DISEASE AND HEALING
   - RADIATION-CHRONIC AND ACUTE
3. PSYCHOLOGICAL FACTORS RELATED TO REMOTE HOSTILE ENVIRONMENT
   - MAINTAIN PRODUCTIVITY OF CREW
     e.g., FOOD, QUARTERS
   - PREVENT PSYCHOPATHOLOGY
     e.g., FIGHTING, DRUG DEP, SEXUAL PROBLEMS
4. PREVENTATIVE MEDICINE

* AFTER NASA-KSC

** AFTER NASA-JSC

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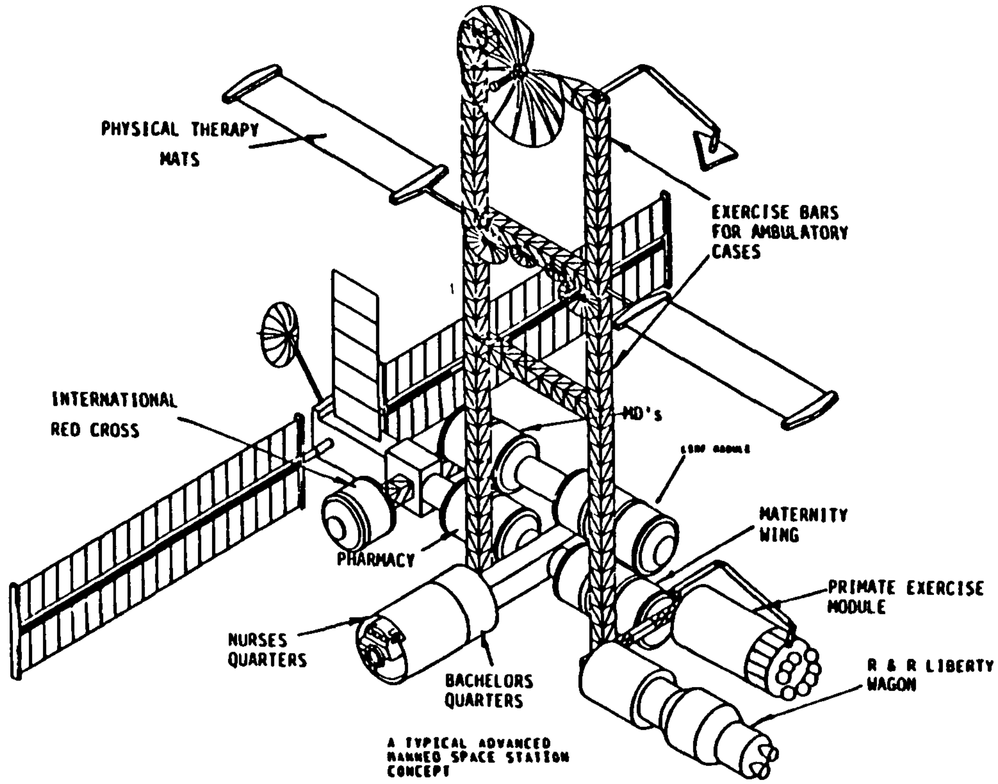
THE ULTIMATE LIFE SCIENCES RESEARCH FACILITY



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TYPICAL MEDICAL PROBLEMS CAUSED BY O-G REQUIRING TECHNOLOGY DEVELOPMENT (PARTIAL LISTING ONLY)

The list presented on the opposite and following page is included only as an indication of the varied medical problems which will be encountered in the weightless environment of the station (assuming no artifical gravity is to be provided, e.g., tethering). This list is from a previous technology conference (AIAA/USAF Man-In-Space Panel, 1982) and is indicative of the types of problems foreseen today based on previous knowledge gained and the extensive studies conducted to date. It is hoped that this list will stimulate further discussion on the needs for future study, research, and equipment technology development as it relates to the health and medical care element of the station.

TYP MED PROBLEMS CAUSED BY O-G (PARTIAL LISTING ONLY)

1. INTRAVENOUS (IV) FLUID INJECTION TECHNIQUES, TITRATION, AND POTENTIAL FOR PULMONARY EDEMA
2. GASTRIC AND OBDOMINAL LAVAGE TECHNIQUES (FLUID-AIR SEPARATION MECHANISM IN THE CLOSED LOOP)
3. FLUID (BLOOD, URINE, AND OTHER BODY FLUIDS) TRANSFER TECHNIQUE
4. MICROGRAVITY PATIENT STRETCHER INTEGRATED WITH CERVICAL TRACTION COLLAR OR TONGS
5. EXAMINING TABLE WITH RESTRAINTS FOR BOTH PATIENTS AND ATTENDANTS
6. X-RAY PICTURES TAKEN IN SPACE FOR DIAGNOSIS OF PLEURISY, HEMOTHORAX, AND INTRA-ABDOMINAL BLEEDING WILL BE DIFFERENT FROM THOSE SEEN ON EARTH, AS WELL AS AUSCULTATORY AND PERCUSSION SOUNDS
7. COMPUTERIZED IV GENERAL ANESTHESIA INSTEAD OF GASEOUS GENERAL ANESTHESIA
8. EYE IRRIGATION METHOD
9. ANY FLUID DROPS PROCEDURES, INCLUDING ANTIBODY TEST, NEED NEW METH OF APPLICATION
10. CORDIOPLMRY RESUSCITATN IN SPACE NEEDS INTEGRATED INSTRUMENTATION (THUMPR, RESP, DEFIBRILLATOR, EKG, URING OTPT, ARTERIAL BLOOD BASES, & $_{p}h$ & PULMNRY ART PRES MONIT
11. VOMITUS CONTROL TECHNIQUE
12. A SPECIALLY DESIGNED "SHOWER" FOR CHEMICAL BURN PATIENT
13. INTEGRATED SURGICAL TRAYS TO RESTRAIN NUMEROUS INSTRUMENTS & CONSUMMABLES

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TYP MED PROBLEMS CAUSED BY O-G (PARTIAL LISTING ONLY) CONTINUED

14. SURGICAL OPERATING TABLE FOR HUMAN PATIENTS
15. TECH TO PROTECT & ENSURE SURV FOR THE FLIGHT CREWMEN AGAINST ATOMIC & LASER/BIOLOGICAL & CHEM ATTACK &/OR OTHER WARFARE HAZARDS ON-BOARD THE SPACE STATION
16. BIO-ISOLATION SYS SEPARATING COMMUNICABLE DISEASE PATIENTS FROM HEALTHY CREW MEMBERS & THE LIFE SUPPORT SYS
17. EVACUATION & SUCTION OF FLUIDS FROM BODY CAVITIES DIFFICULT
18. SURGICAL PREPARATION METHODS OF PATIENT SCRUBBING
19. PANPERITONITIS DUE TO REPTURED APPENDICITIS CANNOT BE OPEN UNLESS GOOD METHODS OF PREVENTING CONTAMONATION OF ATMOSPHERE ARE ESTABLISHED
20. ON-BOARD PREP CAPABILITY FOR IV FLUIDS & BLOOD VOLUME SUBSTITUTES
21. DRUG SHELF-LIFE POTENCY MAINTENANCE & STORAGE METHODS
22. NON-GRAVITY-DEPENDENT MECHANISMS OF CLINICAL LAB TEST EQUIPMT PROCEDURES (HEMATOLOGY, BIOCHEM, IMMUNOENZYMOLOGY, BACTERIOLOGY)
23. TECH OF PSYCHOLOGICAL SUPT FOR THE FLIGHT CREWMEN IN PEACE & WARTIME
24. VITAL FUNCTIONS MONITORING FOR EVA CREW & RESCUE TECHNOLOGY
25. IDENTIFICATION OF MOST APPROPRIATE ZERO-G THERAPEUTIC METHODS IN LIGHT OF PROVEN ONE-G THERAPEUTIC METHODS

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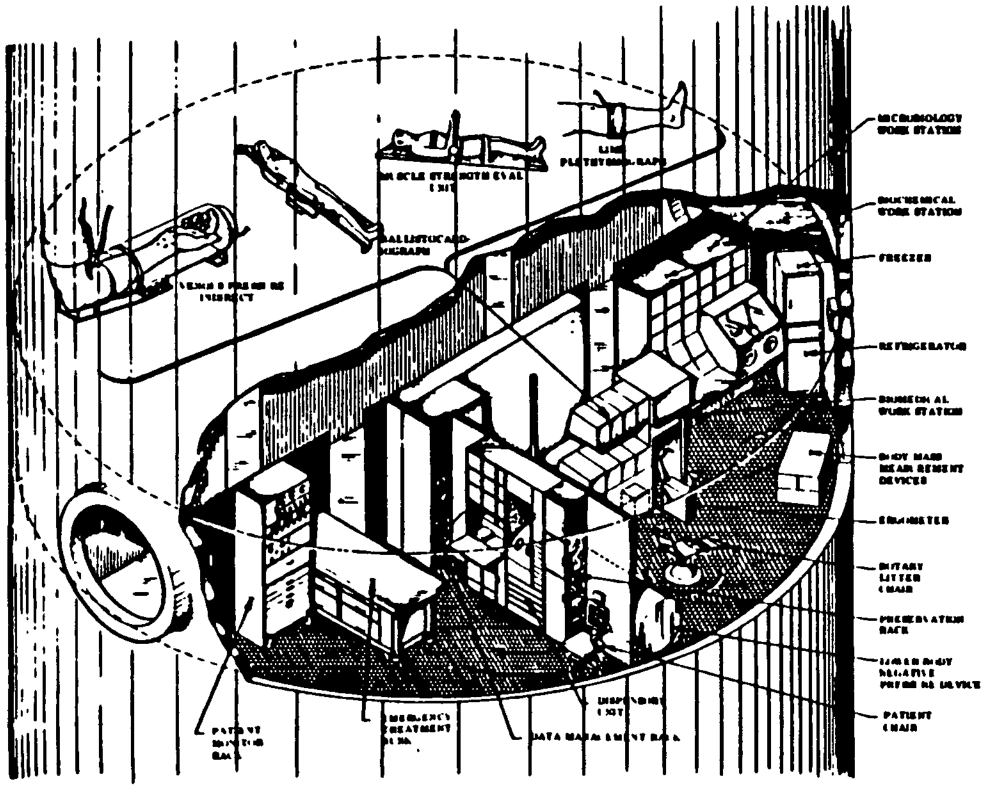
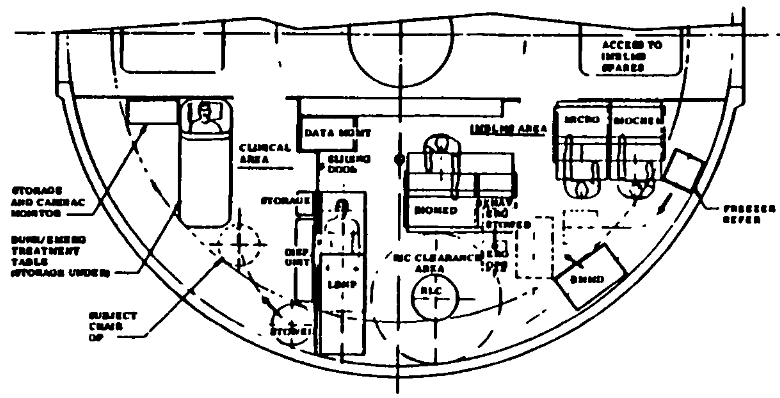
HEALTH CARE - MEDICAL FACILITY - TYPICAL

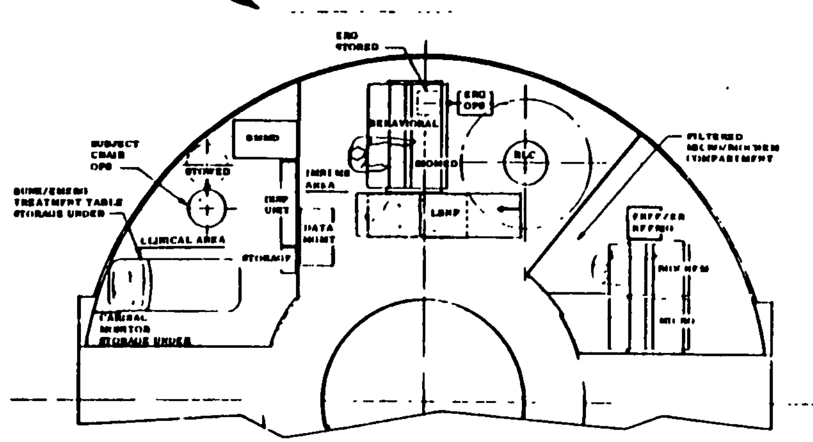
Examples on this and the next page indicate candidate health and medical care facility layouts for both cylindrical and 'stacked can' station architecture. The examples are included only to provide a gross idea as to the nature of a 'full-up' facility of this type. Certainly, the arrangement and layout would be subject to the station architectural configuration. Additionally, the nature of equipment and philosophy of use may change prior to the station implementation phase. Nonetheless, these two examples provide some conceptual understanding of approaches taken previously.

HEALTH CARE - MEDICAL FACILITY (TYPICAL)





ALTERNATE ARRANGEMENTS



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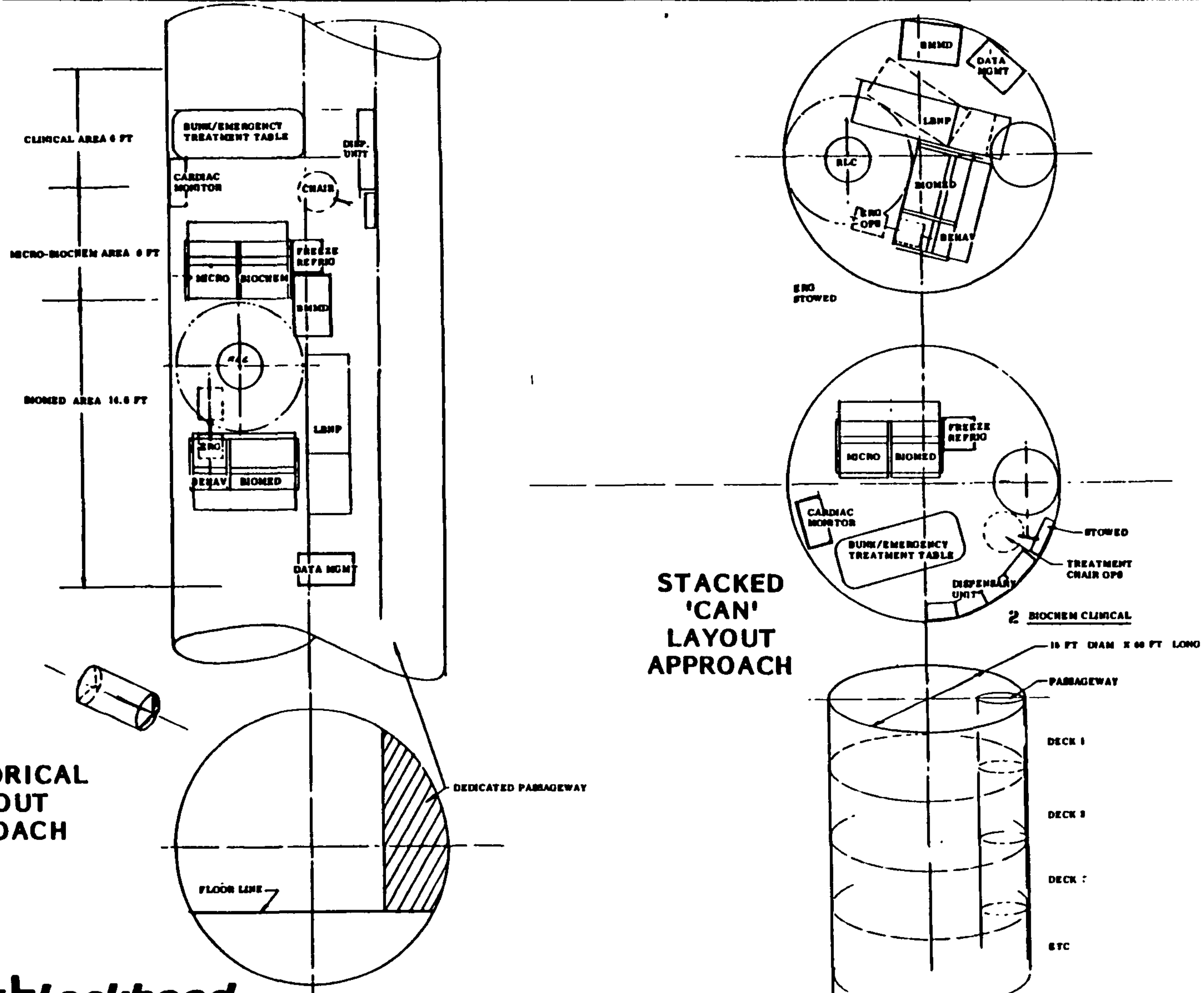
HEALTH CARE - MEDICAL FACILITY LAYOUT (TYPICAL)



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TECHNOLOGY STUDY AREAS

The facing page attempts to indicate (in general) those categories of potential study relative to the health and medical care element. To the right of the chart are two selected examples of potential health maintenance facility/hardware, and procedures associated with the conduct of the medical effort. It is patently obvious that this area can be substantially expanded and much more exhaustive technology listing detail provided. Of concern is the need for prioritization and the careful selection of study and research which can be considered an extension of the Shuttle needs and similarly, logically and systematically evolved to the station era.

TECHNOLOGY STUDY AREAS

PROBLEM DEF & REQTS-PROCEDURES DESCRIPTION

- TRAUMA & INJURY RESULTING FROM CREW OPERATIONS
- INFECTIOUS DISEASES & ILLNESS
- SPACEFLT STRESS & ADAPTATION

MEDICAL CARE FACILITY & HDWR DEVELOPMT

- DEVELOPMT ON NON-ELECTRONIC INSTRU & SUPPORT HDWR
- DEVELOPMT OF ELECTRONIC INSTRU
- MED CARE FACILITY DEVELOPMT
- MED CARE EXPER DEVELOPMT & IMPLEMENTATION

OPS IMPLEMENTATION OF MED CARE FOR FLT CREW

- IMPLEMENT OF BASIC MEDICAL CARE FACILITY
- IMPLEMENT OF ENHANCED MEDICAL CLINIC
- IMPLEMENT OF ADVANCED MEDICAL CLINIC
- IMPLEMENT OF MED XPORT VEH (SPACE AMBULANCE)

EXAMPLES

HEALTH MAINT FACILITY-HDWR

- DIAG IMAGING
- CLINICAL CHEMISTRY
- AUTOM HEMATOLOGY, URINALYSIS
- MICROBIOLOGY
- MISC DIAGNOSTIC EQUIPMT
- MISC THERAPEUTIC EQUIPMT
- PHARMACEUTICALS
- REHYDRATABLE IV FLUID/HYPERALIMENTATION
- EXERCISE EQUIPMT
- MODULARIZATION & TRADE-OFFS OF MEDICAL HARDWARE FOR HMF

HEALTH MAINT FACILITY-PROCEDURES

- TOXICOLOGY & RADIATION
- PHYSIOLOGICAL MONITORING
- MEDICAL LIFE SUPPORT SYSTEMS
- COMPUTER-ASSISTED DIAGNOSTIC/THERAPEUTIC CHECKLIST
- COUNTERMEASURE DEVICES
- CARDIOVASCULAR CONDITIONING
- MUSCULOSKELETAL CONDITIONING
- SURGICAL PROCEDURES
- ORTHOPEDIC PROCEDURES
- TISSUE AND SAMPLE HANDLING

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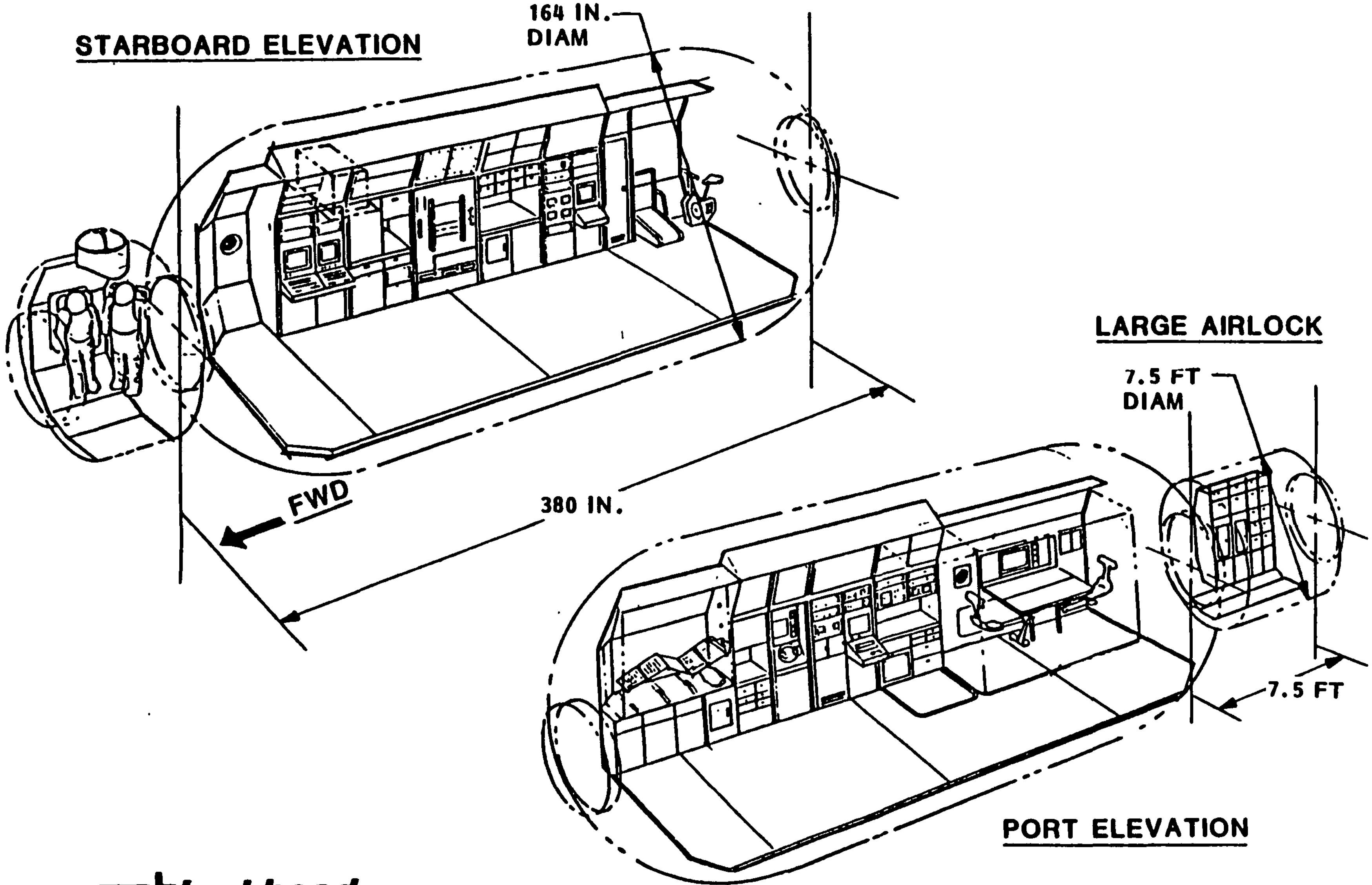
HUMAN RESEARCH & HEALTH CARE LABORATORY (PERSPECTIVE)

This facing page and the next portray a conceptual approach to the development of a human research and health care laboratory for the current space station study effort. The arrangement was developed to coincide with the Orbiter cargo bay limitations (e.g., 14.5 ft. diameter by up to 56 ft. long) for purposes of design constraint. The laboratory is a multi-functional element comprised of the following functional capabilities:

- Health maintenance
- Medical care and treatment
- Behavior evaluation/assessment
- Exercise and conditioning
- Research (biomedical/behavioral)
- Manned integration study
- Technology demonstration
- EVA research and development

The makeup of the laboratory, although conceptual at this time, is indicative of past and present study activities on-going within the NASA, DoD and industry. Certainly, it appears beneficial to consider the potential of an 'entire' lab dedicated to this subject and, therefore, the opportunity to further study and develop a highly flexible and architecturally sensitive approach for the station era. Obviously, much more discussion is needed, particularly in the area of needs, definition of uses, requirements determination, etc. However, it is hoped that this concept will stimulate much added discussion and assist in establishing future technology development planning effort.

HUMAN RESEARCH & HEALTH CARE LAB
PERSPECTIVE



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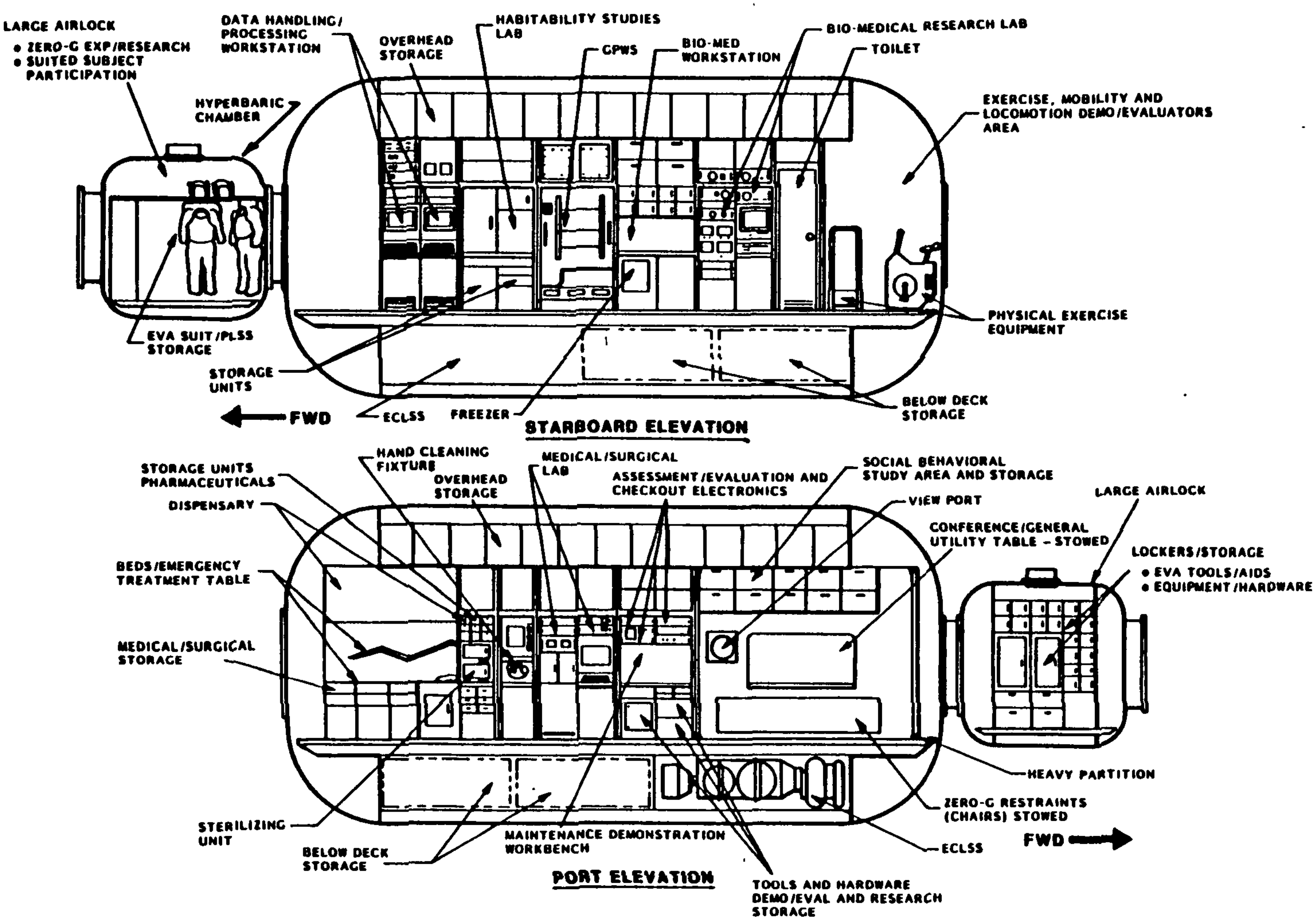
HUMAN RESEARCH & HEALTH CARE LAB
INTERIOR CUT-AWAY



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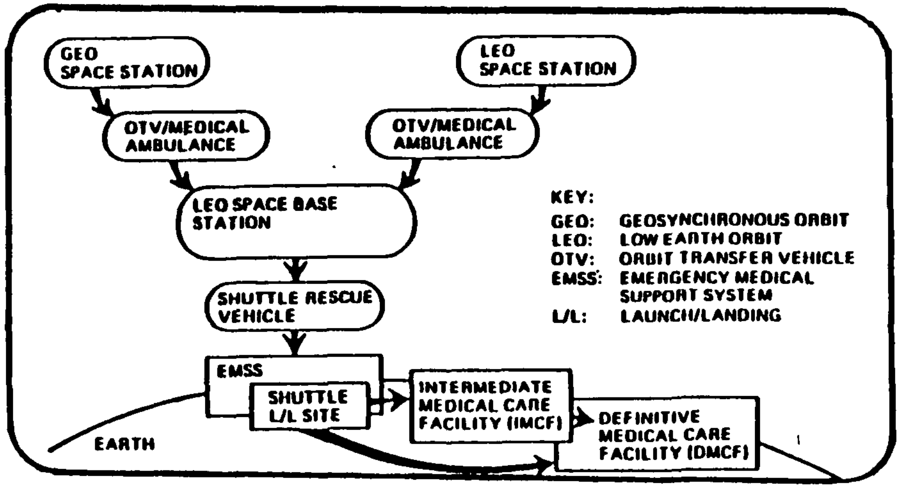
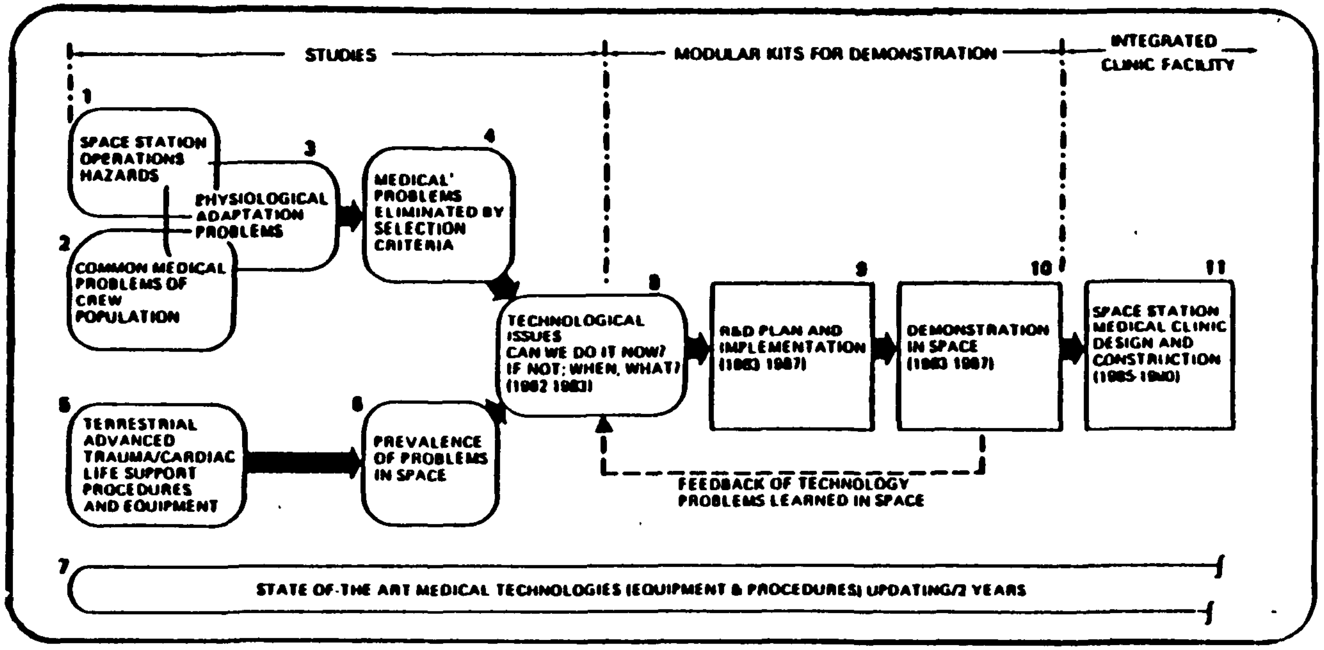
The facing page portrays an example of an integrated medical and health care system applicable to the current concept for the space station. Although this is only one example, it is considered adequate to indicate the nature of the overall effort. A simplified flow diagram of the technology approach keyed to a time scale is also presented. As on the previous page, this material also came from the AIAA/USAF Man-In-Space technology panel effort late last year (1982). As indicated, there appears to be two major issues; and accordingly, pose the challenge for the system concept definition and development. Obviously, this is a major undertaking and needs the closest of inter-agency cooperation, thereby suggesting a strong and well integrated sub-panel (a major panel/group in its own right) be formally 'enhanced' beyond that already existing. Considerable work must accompany this technology development effort, and a significant need exists to coordinate and maintain the momentum already developed.

MEDICAL & HEALTH CARE SYSTEM CONCEPT & TECHNOLOGY DEV



2 MAJOR TECHNOLOGY ISSUES

- QUESTIONS OF DIFFERENCES BETWEEN EARTH & SPACE PHYSIOLOGICAL NORMS
- OPERATIONAL MEDICAL CARE TECHNOLOGY/FEASIBILITY IN SPACE



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The facing page attempts to provide a simplistic categorization of the behavioral environments anticipated for the flight crews. As shown, each of these categories has been broken down into short (but not exhaustive) lists for purposes of stimulating discussion and further identification of appropriate factors. It is most important to note the recent Russian cosmonaut comments from their 211 day flight relative to adequate preparedness for their flight. In particular, their primary stated concern (with respect to this subject) was the feeling that they were not fully or adequately prepared for the continuous daily behavioral 'exposure' and 'problems' encountered during their long stay in orbit. Perhaps future interaction with the Russians may shed further light on this very important area. Obviously, this subject (social-behavioral factors) deserves further definition and delineation relative to the needs for future study, research, and technology development.

SOCIAL-BEHAVIORAL FACTORS

UMBRELLA OF BEHAVIORAL ENVIRONMENTS

- PRE-LAUNCH & TRANSIT
- NOMINAL STATION OPS
- NOMINAL EVA
- EMER OR LIFE THREAT SITUAT
- HOSTILE ACTIVITIES
- COMMAND AUTHORITY

ENVIRONMENT

1. WEIGHTLESSNESS
2. RADIATION
3. CONFINEMENT
4. MAN-MACHINE I/F DESIGN
5. TECHNOLOGY
6. CREW FUNCTIONS/TASKS
7. GROUND INTERACTION
8. EXTERNAL SPHERE FACTORS

PHYSIOLOGICAL

1. BODILY CHANGES
2. BODY 'LANGUAGE'
3. VOICE CHANGES
4. MENTAL STATES
5. MUSCULO-SKELETAL
6. CARDIOVASCULAR
7. ENDOCRINE
8. CONDITIONING NEEDS

INDIVIDUAL

1. MOTIVATION
2. ATTITUDE
3. MENTAL PRE-SETS
4. THINKING PATTERNS
5. COGNITIVE APPROACHES
6. TRAITS

SIGNIFICANT RECENT RUSSIAN COSMONAUT 'FEEDBACK'

CULTURE

1. ASSUMPTIONS
2. BELIEFS
3. VALUES
4. CULTURAL MIX
5. EXPECTATIONS

INTERACTION

1. RELATED
2. UNRELATED
3. HISTORICAL PROGRESSION
4. INTERACT SIGNIFICANCE
5. REAL-TIME DYNAMICS

SOCIOLOGICAL

1. ROLES
2. AUTHORITY
3. SCHEDULES
4. COMM
5. LEISURE
6. TASKS
7. REWARDS
8. CAREER GROWTH
9. MANIPULATION
10. GROUPS VS INDIV
11. ENVIRON IMPACT
12. MIXED CREW

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BEHAVIOR CONCERNS

As indicated in the literature, often symptoms associated with isolation and confinement incorporate symptoms of stress. The facing page presents a listing of these symptoms (also obtained from the AIAA/USAF Man-In-Space panel studies) and, the obvious interrelationships can be inferred. Therefore, the list on the far right of the page was developed to stimulate discussion relative to the needs for continued and future effort in this field as it relates to the station crew and associated need for appropriate technology development.

BEHAVIORAL CONCERNS

SYMPTONS OF ISOLATION AND CONFINEMENT

- HOSTILITY
- SOCIAL WITHDRAWAL
- VACILLATING MOTIVAT
- ANXIETY
- TENSION
- BOREDOM
- SLEEP DISORDERS
- FATIGUE
- DEPRESSION
- MOOD FLUCUATION

COMMONALITY

SYMPTONS OF STRESS

- LOWERED EFFICIENCY
- LACK OF CONCENTRAT
- BOREDOM
- LOWERED EFFICIENCY
- IRRITABILITY
- DEPRESSION
- DEFENSIVENESS
- FEAR
- ANGER
- ANXIETY
- EXCESSIVE EMOTION
- TENSION

RESEARCH AREAS

1. CREW MIX (FEMALE/MALE/MULTI-NATIONAL)
2. CREW SIZE
3. CREW COMPOSITION
4. CREW FUNCTION ALLOCATION & DEFINITION
5. ORGANIZATION & TEAM BUILDING
6. COMMAND/AUTHORITY/LEADERSHIP
7. CHAIN OF COMMAND PATH
8. STRESS & STRESS HANDLING
9. WORK SCHEDULING
10. EXPECTED VS ACTUAL 'OUTPUT;
11. LEVELS OF 'INPUT' - ADEQUATED TO REDUCED
12. COMMUNICATIONS (e.g.)
    o LEVELS o CHANNELS o PATH o CLARITY
13. CROWDING
14. ISOLATION/LINLINESS
15. WORK HOURS/SHIFTS
16. LEISURE/EXERCISE
17. RESPONSIBILITY
18. TIME CONSTRAINTS/PRESSURES
19. ROTATION CYCLES
20. HABITABILITY
21. PHYSIOLOGICAL RESPONSES
22. HUMAN ERROR - TYPES/CONDITIONS/FACTORS
23. CONFLICT MANAGEMENT

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BEHAVIORAL STUDY - TECHNOLOGY DEVELOPMENT

(TYPICAL)

The facing page and next two pages portray a sample list of candidate behavioral studies as they relate to the potential interaction of the station flight crews to one another, groups, and individually to the environment. The categories and associated study factors are not intended to be exhaustive, but rather to provoke further discussion and identification of additional factors worthy of subsequent study, research, and technology development. Again, the data was synopsized from the efforts conducted in support of the AIAA/USAF Man-In-Space technology panel meeting (1982).

BEHAVIORAL STUDY-TECHNOLOGY DEV (TYPICAL)

CREW MIX

ANALYSIS OR PRESENT REMOTE GROUPS WITH MIXED CREWS (FEM/MALE & MULTI-NAT) TO:
- DETERMINE CONDITIONS THAT CREATE PROBLEMS
- DETERMINE CONDITIONS CONDUCIVE TO EFFECTIVE TEAMS

CREW ROTATION

ANALYSIS OF CREW ROTATION MODES IN PRESENT REMOTE STATIONS TO DETERMINE:
- TIME PHASING
- INTERFACING METHODS
- PRIOR GROUP FAMILIARITY
- SCHEDULING
- OVERLAP
- COMMUNICATIONS

TEAM BUILDING

ANALYSIS OF TEAM BUILDING CONCEPTS TO:
- ESTABLISH TRAINING & TRAINING PROTOCOL
- IDENTIFY METHODS FOR INITIATING/DEVELOPING SMOOTH TEAM INTER/COORD

CAREER & REWARD DEVELOPMT

ANALYSIS OF THE WAYS CREW (CIVILIAN & MILITARY) VIEW SPACE SERVICE:
- CAREER DEVELOPMT
- ADVANCEMENT
- PERSONAL 'REWARD'-GOAL/OBJECT
- NEAR-TERM AWARD (ON STA) FOR 'GOOD" PERF
- ROUTINE SPACE OPS 'VALUE CHANGES' VS 'WHITE SCARF DAYS'

CONFLICT MANAGEMT

ANALYSIS OF CONFLICT & PROBLEM MANAGEMENT TO DETERMINE:
- ALTERNATE TECHNIQUES FOR RESOLUTION THAT ARE CREW TRANS & CREW USE
- METHODS FOR EARLY IDENTIFICATION OF PROBLEMS

AUTHORITY

ANALYSIS OF PRESENT/PAST WORK ACCOMPLISHED ON AUTHORITY & COMMAND STR TO:
- PROVIDE ALTERNATIVE METHOD/DPPROACHES
- WORKABLE APPROACHES FOR GROUPS IN SIOLATION & WITHIN STRESS ENVIRON

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BEHAVIORAL STUDY-TECNOLOGY DEV (CONTINUED)

STRESS

ANALYSIS OF RESEARCH THAT ATTEMPTS TO:

- MITIGATE CAUSES & EFFECTS OF STRESS
- IDENTIFY AREAS OF PRE-FLT TRNG
- DETERMINE METHODS TO HANDLE INITIATED STRESS
- IDTFY STR 'REDUCERS'

ON-ORBIT WORK FACTORS

ANALYSIS OF PRESENT/PAST INDUSTRIAL JOB & TEAM WORK ST OF REMOTE/INDEP GROUPS TO:

- STIMULATE OR ENHANCE EFFECTIVENESS
- DEVELOP EFFECTIVE TECH TO ACHIEVE MORE EFFECTIVE:
  - PLANNING - VARIETY - SCHEDULING - DEGREE OF AUTONOMY (AS REQD)
  - GROUP DECISIONS - ROLES - DEV OF LABOR - HUMAN ERROR HANDLING

COMM

ANALYSIS OF COMMUNICATION PROBLEMS & ATTEMPTS AT SOLUTION RELATIVE TO:

- FACE-TO-FACE
- VOICE
- REMOTE & COMPUTER I/Fs
- BODY LANGUAGE
- TELEVISION
- ZERO-G INFLUENCERS

TECHNOLOGY

ANALYSIS OF MAN-MACHINE ENHANCEMENT THROUGH DESIGN RELATIVE TO:

- OPTIMIZATION OF MAN-MACHINE I/F
- REDUCTION OF FATIGUE/BOREDOM
- DETERMINING LIMITS/BOUNDRIES OF INFO PROCESSING & LOADS
- PROVIDING HDWR/TECHNIQUES FOR BETTER UTILIZATION OF ZERO-G
- REDUCTION OF MUNDANE TECHNIQUES & BETTER UTILIZATION OF MAN-IN-THE-LOOP

LEISURE

ANALYSIS OF LEISURE FUNCTIONS TO DETERMINE:

- NEEDS
- TYPES
- OPTIONS
- FREQUENCY
- TIME/DURATION
- JOB RELATED VS INDEPENDENT

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BEHAVIORAL STUDY-TECHNOLOGY DEV (CONTINUED)

EXERCISE

ANALYSIS OF EXERCISE FUNCTIONS TO DETERMINE:

- NEEDS
- TYPES
- RELATIONSHIP TO STRESS REDUCTION
- FREQUENCY
- TIME/DURATION
- RELATIONSHIP TO MEDICAL PGR

ENVIRONMT

ANALYSIS OF STUDIES RELATIVE TO:

- COLOR/SHAPE/TEXTURE
- ILLUMINATION
- NOISE CONT/REDUCTN
- NOISE MASKING
- SOUND BACKGRND
- OLAFACTORY FACTORS
- GARMENTS (TYPE/STYLE/TEX)
- HABIT VOL
- WEIGHTLSNS CONSTR/ADV

BEHAVIORAL

ANALYSIS OF PRESENT REMOTE, INDEPENDENT & SPACE 'BASED' BEHAVIOR RELATIVE TO ENHANCING BEHAVIOR &/OR REDUCING BEHAVIORAL DEVELOPED PROBLEMS:

- MORALE
- ATTITUDE
- MENTAL RECEPTIVITY
- THINKING PAT
- COGNITIVE APPR
- DEPRESSION
- STRESS
- SLEEP DISORDERS
- MOOD FLUCUATION
- HOSTILITY & ANGER
- ANXIETY & TENS
- SOCIAL WITHDRAWAL
- IRRITABILITY
- DEFENSIVENESS
- LOWERED EFFICIENCY
- MOOD FLUCTN
- PRE & POST MENSR TENS
- JEALOUSY
- LONLINESS
- '2 AGAINST 1 SYNDROME'
- PHYSIO-PSYCHO IND PROB

EMERGENCY

ANALYSIS OF REMOTE &/OR ISOLATED GROUPS/INDIVIDUALS RELATIVE TO:

- ANXIETY/FEAR
- HUMAN ERROR TENDENCIES
- 'PURE PANIC'
- HOPELESSNESS
- STRESS REACTION CAPABILITY
- MENTAL SET VS INGEN
- TIME PRESSURES
- AUTHORITY/COMMAND FOLLOWING

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CONCLUSIONS/RECOMMENDATIONS

A. A SUBSTANTIAL NUMBER OF CANDIDATE HUMAN CAPABILITY TECHNOLOGY STUDY/ DEVELOPMENT CATEGORIES & AN EVEN GREATER NUMBER OF SUB-FACTORS HAVE BEEN PRESENTED

B. THESE AND OTHER FACTORS DISCUSSED TODAY AND TOMORROW SHOULD BE COMPILED AND EXAMINED:

- CATEGORIES SHOULD BE ESTABLISHED
- AGREEMENTS (AT LEAST TENTATIVE) SHOULD BE REACHED ON THE MAJORITY OF SUB-CATEGORY LISTS
- SOME ACCORD OUGHT TO BE ACHIEVED IN DETERMINING CERTAIN PRIORITIES

C. THE PANEL AND 'COMMITTED MEMBERS' SHOULD CONTINUE AS A TEAM:

- FURTHER IDENTIFY/DEFINE THE TECHNOLOGIES
- PREPARE TECHNOLOGY STUDY/DEVELOPMENT SCHEDULES
- DELINEATE COST FACTORS FOR THE TECHNOLOGIES
- MAINTAIN CONTINUED LIAISON WITH AIAA/USAF MAN-IN-SPACE TECHNOLOGY PANEL
- PREPARE INTERIM & INFORMAL PANEL INPUTS

D. THE NASA PANEL SHOULD CONSIDER OBTAINING MODEST FUNDS FOR TECHNOLOGY PANEL EFFORTS

- ONE OF THE PROBLEMS OF THE AIAA/USAF MAN-IN-SPACE TECHNOLOGY PANEL!

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